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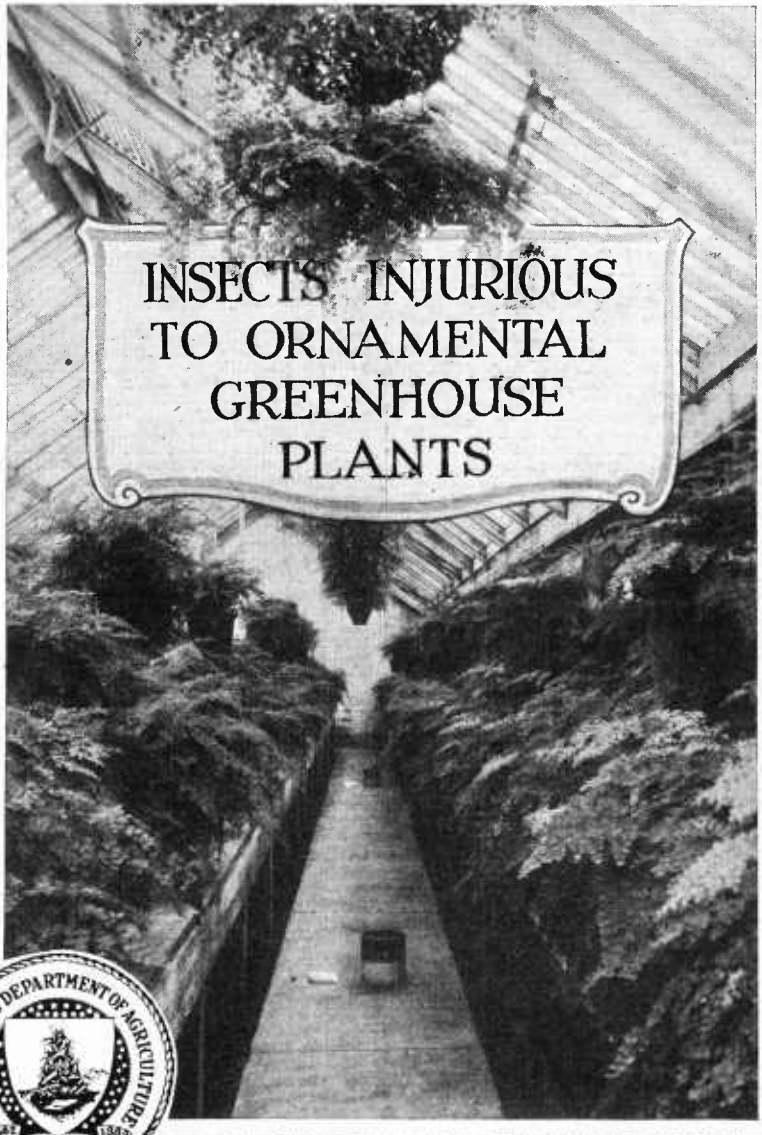

INSECTS INJURIOUS TO ORNAMENTAL GREENHOUSE PLANTS

INDEX.

INSECTS INJURIOUS TO ORNAMENTAL GREENHOUSE PLANTS.

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CONTENTS.

NEED OF UNDERSTANDING INSECT PESTS.

STATISTICS assembled by the Bureau of the Census in 1919 indicate that there were 162,368,593 square feet, or 3,727.4 acres, in the United States covered by greenhouses, including frames and sashes, devoted to the growing of ornamental plants and vegetables. The income from the crops grown in these houses for the year 1919 was $77,380,230, of which $61,892,352, or practically 80 per cent, represented flowering plants and cut flowers. The annual loss due to insect attack for the period under review may be conservatively estimated at 10 per cent of the value of the crop, or more than $6,000,000.

The temperature conditions which prevail in greenhouses approach those which obtain in the Tropics and subtropics; hence they afford an ideal environment for the development and rapid multiplication of insects. Inasmuch as the growing of plants under glass represents intensive culture, involving a large initial outlay of capital with continual expense for fuel, water, labor, fertilizers, and repairs, every square foot of space involved must produce its full quota. It is imperative, if the profits of the year are to be considered, that insect enemies receive prompt attention. Much of the loss which accrues from insect attack could be eliminated by adopting timely measures. These losses are not necessarily confined to sudden outbreaks of insects which may result in a partial or total loss of the crop involved, but much injury is chargeable to common pests such as plant-lice, white flies, and red spiders, the destructiveness of which is often underestimated by many plant growers.

Insects in great variety infest greenhouses, and the control of each kind depends on its habits and mode of attack. Plants differ mark-

edly, moreover, in their ability to withstand without injury the application of insecticides which would be effective in controlling their insect pests, and this fact must be taken into account. Furthermore, as the margin of safety in the use of insecticides under glass is narrower than out of doors, the greenhouse man must exercise great caution in treating his plants.

It is important, therefore, that the florist be familiar with the forms and habits of the insect pests attacking his plants, the most effective insecticide to employ in each case, the object to be accomplished in applying it, the opportune time, the proper mode of application, and the value of clean culture as a practical preventive measure. Attention to these points will add much to the grower's efficiency in fighting greenhouse insects.

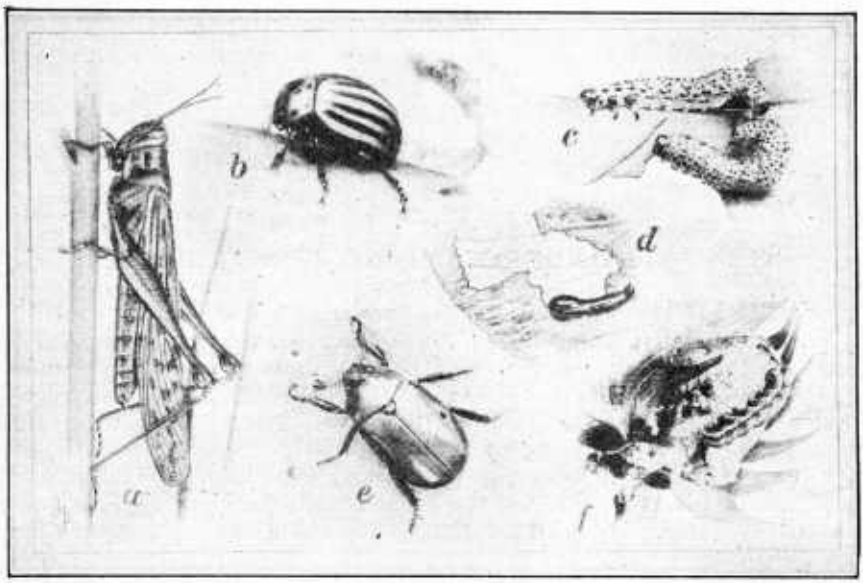

FIG. 1.—Examples of insects with biting mouth parts: *a*, Grasshopper; *b*, *e*, beetles; *c*, *d*, sawfly larvæ; *f*, caterpillar. (Quaintance and Siegler.)

HOW INSECTS ARE SPREAD.

Insects may be introduced into greenhouses in one or more of the following ways: (1) On infested cuttings or plants which may be purchased from other florists or transferred on plants from infested houses or on so-called "boarders"; (2) in the soil or manure used in replenishing or refilling beds; (3) by being harbored in the house from one crop to another; (4) on infested weeds or other vegetation growing in close proximity to greenhouses, from which insects may fly, crawl, or be blown in through open ventilators; (5) by transfer of plants which are started outdoors and subsequently moved into the greenhouse, or vice versa, as, for example, roses, carnations, chrysanthemums, crotons, and other ornamental plants; (6) by mechanical means on the hands or tools used by the gardener.

HOW INSECTS FEED.

For the intelligent employment of insecticides it is important that the plant grower should understand the character of the mouth parts of insects, since this determines the kinds of insecticides to be used. Generally speaking, insects secure their food in one of two ways: (1) By actually biting and devouring portions of the plant or (2) by piercing the tissues and sucking out the vital juices from the interior of the plant.

The biting or gnawing insects actually masticate and swallow portions of the solid substance of the plant; for example, the leaves, flowers, and bark. These insects include the larvæ or caterpillars of moths and butterflies, beetles and their grubs, sawflies and their larvæ, and grasshoppers (fig. 1). Biting insects which feed in situations where poisons may be applied and eaten along with part of the plant may be destroyed by arsenical or stomach poisons. Root

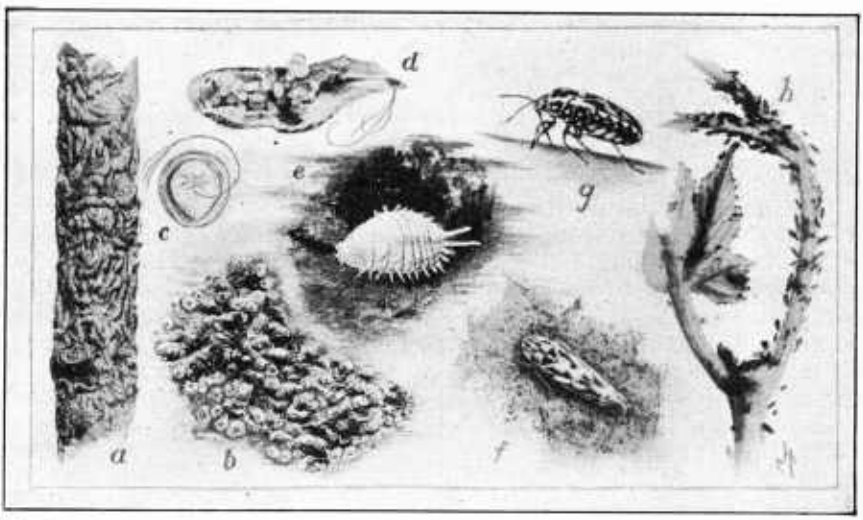

FIG. 2.—Examples of insects with sucking mouth parts: *a–e*, Scale insects; *f*, leafhopper; *g*, plant-bug; *h*, aphids. (Quaintance and Siegler.)

or soil infesting forms, on account of their subterranean habits, require a different treatment.

Sucking insects injure plants by the gradual extraction of the juices from the leaves, bark, and roots, and include scale insects, leafhoppers, plant-lice or aphids, white flies, plant-bugs, and plant-feeding mites (fig. 2). These insects are provided with beaks or bristles, which are inserted into the tissues of the plant and through which they suck or pump the vital juices. For insects of this class it is necessary to use so-called contact insecticides, which will act externally on their bodies, penetrate their breathing pores, or otherwise cause their destruction. Such an insecticide is applied to the insect and only incidentally to the plant, since it would be impossible to hit one without the other. It is obvious, therefore, that success depends upon thorough application of the insecticide so that it will come in contact with all insects present on the plant.

Another method of controlling insects infesting plants grown under glass is to take advantage of the suffocating qualities of certain gases or fumes which may be liberated in the house, such as hydrocyanic-acid gas and tobacco smudges.

PREPARATION OF INSECTICIDES.

STOMACH POISONS.

Arsenate of lead as a spray is probably the most extensively used of the stomach poisons. It can be obtained commercially in either the paste or the powdered form. The latter is to be preferred, owing to greater convenience in handling. Arsenate of lead is superseding Paris green and other active forms of arsenicals because it can be used with greater safety on plants, possesses good adhesive qualities, and can easily be combined with certain contact insecticides and fungicides. If eaten by the insects it will operate against caterpillars, cutworms, leaf-tyers, leaf-rollers, many beetles, and other insects which devour the foliage. As a spray it may be used in the following proportions:

2 pounds (powdered) to 50 gallons water.
⅔ ounce to 1 ounce, or 10 level teaspoonfuls, to 1 gallon water.

In preparing a solution the arsenate should first be made up into a thin paste by the addition of a small quantity of water and then diluted to the required strength. On smooth foliage or leaves with a waxy surface the liquid does not stick or spread well. This difficulty is easily overcome by adding a "sticker" such as fish-oil soap or any common laundry soap at the rate of 2 pounds to 50 gallons of liquid. For smaller quantities use from ½ to 1 ounce for each gallon of spray.

Objection is occasionally made to the use of arsenate of lead in the form of spray because of the deposit which remains on the foliage. This is not serious, however, since it is usually applied on the younger plants, and leaves so affected are left behind as the plants grow. While the normal dilution ranges from 1 to 2 pounds to 50 gallons of water, this amount may be increased for some insects, such as the strawberry rootworm.

Arsenate of lead also finds a limited use in poisoned baits for sowbugs and cutworms. Pieces of fresh-cut vegetables are dusted with the powder, or clover is dipped into a strong solution. Combinations of the powdered form with other ingredients such as tobacco dust, or superfine sulphur, with lime as a filler, and dusted on by means of a modern hand blower gun, serve as a combined stomach and contact poison. (See mixtures under "Sulphur.")

Calcium arsenate (arsenate of lime) may be substituted for lead arsenate for the control of some leaf-feeding insects. Its use, however, has not been fully demonstrated, although it has been determined in preliminary tests on roses and chrysanthemums that as a dust it does not injure the foliage. Owing to its fineness, it is admirably suited for dusting when combined with superfine sulphur.

Paris green is an arsenical compound which has been widely used by florists in the past but is now gradually falling into disuse owing to its tendency to burn the tender foliage and plants. It settles quickly, and therefore has to be constantly agitated during spray-

ing. It is probably more efficient as a poisoned bait for cutworms, sowbugs, slugs, and millipeds, and for this purpose should be mixed dry, using 1 part of Paris green with 9 parts of sugar, and sprinkled over the soil. In its application care should be exercised to prevent it from coming in contact with tender foliage, otherwise severe burning may result. It is used as the active ingredient of poisoned bait for the control of cutworms and also of grasshoppers. For use as a spray, Paris green is prepared as follows:

Large quantities.	Small quantities.
5 to 6 ounces to 50 gallons water.	1 teaspoonful to 3 gallons water.
1 pound lump lime.	2 to 3 ounces lump lime.

Paris green spray, when prepared by the following formula, is an effective means of controlling thrips, viz, Paris green 2 tablespoonfuls, brown sugar 2 pounds, water 3 gallons.

White arsenic.—White arsenic is a very active stomach poison, but its use on foliage is precluded because of the severe burning likely to follow. On account of its cheapness it is finding increased use in poisoned baits as a substitute for Paris green.

Poisoned bran mash.—Besides being an excellent remedy for grasshoppers, poisoned bran mash is also an effective poison for the control of cutworms, sowbugs, millipeds, and ants. Following are the ingredients of this bait:

Paris green or white arsenic	¼ pound.
Dry bran, alfalfa meal, or middlings	1 peck.
Sirup or molasses	1 pint.
Water	4 to 6 quarts.
6 to 8 oranges or lemons.	

The white arsenic and dry bran are first mixed thoroughly in a container. In another vessel stir a pint of cheap molasses or sirup into 4 to 6 quarts of water. Then prepare a mash by slowly adding the mixture of sirup and water to the poisoned bran. Allow it to stand for several hours to permit the bran to take up the arsenic. Lemons or oranges finely ground up are added to make the bait more attractive, but may be left out if the bait is to be used against cutworms. Scatter thinly over the surface of the soil along the rows of plants after sundown.

Hellebore is recommended where few plants are concerned. It is a powder made from the roots of the white hellebore plant, and may be used either as a dust or as a spray, being effective against immature larvæ of many leaf-feeding insects. It is made up as follows:

Liquid:	
Hellebore	1 ounce.
Water	1 gallon.
Dry:	
Hellebore	1 ounce.
Flour or air-slaked lime	5 to 10 ounces.

Phosphorus paste.—Several proprietary phosphorus pastes are offered on the market, which contain approximately 1 per cent of phosphorus and which are very effective in the control of cockroaches. Small amounts of the paste are placed on paper along the beds and the roaches feeding at night take freely of the poisoned bait.

CONTACT INSECTICIDES.

Tobacco extracts or nicotine solutions are very generally used for the control of many soft-bodied sucking insects, and florists find them particularly valuable against plant-lice or aphids, thrips, and rose slugs. They are recognized as standard contact sprays, and can be purchased as liquid concentrates under many proprietary names, either in volatile or in nonvolatile form. Such concentrates are easily diluted to the required strength or may be combined with many standard stomach poisons and fungicides.

Volatile nicotine.—The volatile or "free" nicotine as a liquid is largely used for fumigation by painting it on the hot steam pipes or by vaporizing it over lamps. It is also used for spraying but not to such a great extent as the stable or nonvolatile forms. Directions for its use are given on the labels of the containers in which it is purchased.

Nonvolatile tobacco extracts or nicotine solutions are used, diluted with water, as follows:

Nicotine sulphate containing 40 per cent of nicotine:
1 to 1½ teaspoonfuls to 1 gallon water.
1 fluid ounce to 8 gallons water.
¼ pint or 4 ounces to 25 gallons water.
Add soap at the rate of 1 ounce per gallon of solution.

The above dilutions are based on highly concentrated extracts containing not less than 40 per cent of nicotine, which are available in convenient packages and sold by dealers in farm machinery and insecticides. The purpose of adding soap to nonvolatile extracts is to increase the spreading and sticking qualities of the solution.

Thoroughly dissolve the desired amount of fish-oil or common laundry soap in hot water, and then add the necessary quantity of tobacco extract. Apply while hot or warm in the form of a fine mist spray. Apply late in the afternoon or on cloudy days, to prevent unnecessary burning from sunlight.

Nicotine oleate.—A stock solution of nicotine oleate is prepared by mixing 10 parts of 40 per cent volatile or "free" nicotine solution with 7 parts of oleic acid or red oil. This combination results in a product similar to soft soap. This is then diluted with equal parts of rain or soft water.* For spraying, the stock solution as thus prepared is further diluted as follows:

8 tablespoonfuls stock solution to 1 gallon water (for 1 to 500 strength).
4 tablespoonfuls stock solution to 1 gallon water (for 1 to 1,000 strength).

H. F. Dietz in a recent publication [1] states that florists are obtaining a good control by spraying with nicotine oleate, using 1 fluid ounce of the stock solution to 2 gallons of water.

This new contact insecticide has been developed within the last few years.[2] It may be prepared from any nicotine preparation containing "free" nicotine. It dissolves in soft water, forming a soapy solution which may be used to emulsify an animal, vegetable, or mineral oil, especially kerosene.

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[1] Dietz, Harry F. Greenhouse inspection in Indiana. *In* Indiana, Department of Conservation, Report of Division of Entomology and List of Nurserymen for 1921, pp. 8–15. 1922.

[2] Moore, William. A promising new contact insecticide. *In* Journal of Economic Entomology, June, 1918, vol. 11, No. 3, pp. 341, 342.

Kerosene nicotine oleate.—A stock emulsion of kerosene nicotine oleate is prepared from two separate solutions and afterwards diluted for use, as follows:

Stock emulsion:	
Solution 1—	
Kerosene	8 parts or 1 gallon.
Oleic acid	1 part or 1 pint.
Solution 2—	
Volatile nicotine (40 per cent)	2 parts or 2 pints.
Water	8 parts or 1 gallon.

1 pint of stock emulsion to 10 or 12 gallons of water.

Solution 1 is prepared by slowly pouring the oleic acid into the kerosene, stirring constantly. In another vessel make up solution 2 by adding the volatile nicotine to the water. The stock emulsion is then prepared by stirring solution 1 into solution 2 and bringing the mixture to a creamy consistency by churning it rapidly for several minutes, pouring from one vessel to the other, or pumping the liquid back upon itself through a bucket pump.

For use against such soil pests as sowbugs, earthworms, ants, and millipeds use 1 pint of the stock emulsion to 10 or 12 gallons of water and spray thoroughly the ashes or sand under the pots or the soil beneath the benches. Owing to the strength of this emulsion, one should avoid getting it on growing plants. For mealybugs use 1 quart to 5 gallons of water.

Kerosene emulsion.—A stock emulsion of kerosene is prepared from kerosene, fish-oil soap, and water in the following proportions:

Stock emulsion:	
Kerosene	2 gallons.
Fish-oil soap	½ pound.
Water	1 gallon.

Cut the soap into chips or shavings and dissolve in the water by boiling. Remove the hot solution from the fire and add the kerosene very slowly while stirring constantly. It is important to have the solution hot as well as to agitate it thoroughly while adding the oil. After all the oil has been added pump the emulsion through the nozzle back into a suitable container for several minutes. This will give a creamy emulsion, which may be kept tightly bottled until ready for use.

Kerosene emulsion deteriorates with age and will show free oil at the top. This is commonly the case with some of the proprietary emulsions, and this free oil is the cause of much injury to plant tissues when applied. It has been found that the emulsion may be reclaimed by reheating and agitating, with or without additional soap.

The foregoing stock emulsion contains 66⅔ per cent oil and must be diluted with water to the desired strength before using. The following table gives the proper dilution for the desired strength, using 1 part of stock emulsion in each case:

Strength.	Quantity of water.
1 per cent	66⅔ parts.
2 per cent	32⅓ parts.
5 per cent	12⅓ parts.
10 per cent	5⅔ parts.

Kerosene emulsion is one of the most effective contact insecticides, but can not be used safely on succulent plants such as coleus, helio-

trope, and begonia. Crotons, palms, rubber plants, and other hardier plants are not injured by even a 10 per cent emulsion. Diluted to 5 per cent, this emulsion is effective against immature scales and red spiders, and a 1 per cent emulsion can be used successfully against aphids, ants, and thrips. Kerosene emulsion should be applied preferably in the late afternoon, and the plants should be thoroughly syringed with water on the morning following. Soil overrun with ants may be entirely freed of these pests without injury to any of the plants by using a 5 per cent emulsion.

Soap solution.—A soap solution prepared by simply dissolving either fish-oil soap or common laundry soap in water serves as a sticker, and is at the same time a fairly satisfactory remedy for aphids, the crawlers of scale insects, and red spiders. Following are the proportions:

Fish-oil soap or hard soap	1 pound.
Water	2 to 4 gallons.

When used in the more concentrated forms soap solution should be applied while still warm, otherwise it is likely to become stiff or gelatinous and clog the spray nozzle. It is advisable to syringe the plants with water the day following the application to avoid possible injury to tender foliage and plants. Care should also be exercised not to allow the soap solution to collect around the roots of the treated plants.

Mercuric chlorid solution.—Mercuric chlorid is known commercially as bichlorid of mercury or corrosive sublimate. It acts as a contact insecticide against soil-inhabiting pests, such as earthworms, slugs, snails, and the larvæ of fungus gnats, if the soil is drenched with the solution at the following strength:

1 ounce dissolved in 8 gallons water (1 to 1,000).
6¼ ounces dissolved in 50 gallons water (1 to 1,000).

For treating only a few plants dissolve 1 tablet (containing 7.3 grains of bichlorid of mercury) in 1 pint of water to make the above strength. These tablets are obtainable at drug stores.

As **this chemical is a deadly poison** it should be safeguarded in its preparation and handling. This compound corrodes metals, and should preferably be prepared in a glass or glazed vessel, which should be thoroughly cleaned immediately after use.

Tobacco dust.—While primarily used against root-inhabiting insects, tobacco dust also finds practical application as a dust to destroy thrips and aphids. It may be used in the pure undiluted form or mixed with a carrier, such as superfine sulphur, arsenate of lead, lime, or flour. (See mixtures under "Sulphur.")

Nicotine dust.—The use of nicotine sulphate in a dust, which is made up by impregnating finely pulverized kaolin or China clay and lime, hydrated or air-slaked, with nicotine sulphate solution containing 40 per cent of nicotine, has recently proved successful in controlling the melon and cabbage aphids, onion thrips, cucumber beetles, and some other insects on outdoor crops. These results suggested the possibility of using it in greenhouses for the control of aphids and thrips, as well as some soft-bodied caterpillars. Recent greenhouse experiments by the writers indicate that a dust containing 5 per cent nicotine sulphate, with hydrated lime, hydrated lime and

kaolin, or hydrated lime and sulphur as a carrier, kills more than 95 per cent of the brown chysanthemum aphids within two days. The action is similar to that of nicotine sulphate spray, but considerably more rapid. It possesses the additional advantage of being applied more easily, because hand dusters are easier to operate and lighter in weight than hand sprayers. Arsenate of lead and sulphur may be mixed with the nicotine dust and applied dry for different types of insects and certain diseases like mildew. A dust containing from 2 to 5 per cent by weight of the nicotine sulphate solution should prove effective under greenhouse conditions. Under such conditions this material causes considerable irritation when inhaled, hence especially devised respirators are now procurable and should be worn to overcome this difficulty. Information concerning its use and preparation is contained in Farmers' Bulletin 1282, United States Department of Agriculture. "Free nicotine," containing 40 per cent nicotine, which is more volatile than nicotine sulphate, is also being used in combination with various dust carriers.

Pyrethrum.—Pyrethrum powder consists of the ground flower heads of certain species of Pyrethrum plant, and is also sold under the names of buhach, Persian insect powder, Dalmatian insect powder, and insect powder. It is used in liquid form and also as a dust, as follows:

Liquid:

Pyrethrum	1 ounce.
Water	1 gallon.
Soap	½ ounce.

Dry:

Apply the pyrethrum powder with small powder guns.

The active ingredient of pyrethrum is volatile and affects insects through their breathing pores. Owing to its volatile nature, it should not be exposed to the air, and should, therefore, be kept in a tightly closed receptacle and should be fresh when used. As a dust it is preferably used to kill or repel ants, aphids, and certain other insects. In water suspension it has proved a good remedy for the control of the Florida fern caterpillar and certain other leaf feeders. One ounce of the powder is steeped in a small amount of water for 10 or 15 minutes, and then enough water is added to make a gallon. This is applied as a fine mist spray. This material is not poisonous to man or the higher animals.

Sulphur.—For the destruction of the red spider on the foliage of roses and other plants finely powdered or superfine sulphur is now extensively used, especially by commercial rose growers. Commercial ground sulphur is as effective as the more expensive flowers of sulphur, provided it is as finely powdered. It may be used either pure or diluted with equal parts of a carrier, such as hydrated lime, gypsum, kaolin, or flour, and applied with a hand-blower gun or bellows duster. Either of the following mixtures may be used:

No. 1:	
Superfine sulphur	9 parts.
Arsenate of lead	1 part.
No. 2:	
Superfine sulphur	8 parts.
Arsenate of lead	1 part.
Tobacco dust	1 part.

Hydrated lime or kaolin in 4 to 5 parts may be substituted, in each of the above formulas, for a similar amount of sulphur, which it is intended to replace.

Sulphur mixed with water at the rate of 1 ounce to 1 gallon and sprayed on infested plants is a good remedy for red spiders. Soap at the rate of 1 to 2 ounces per gallon may be added.

Vegetable-oil solution.—There are several commercial insecticides on the market which have as their main active ingredient certain percentages of vegetable oils in combination with soap and other substances. These are diluted or dissolved in water and are efficient against many soft-bodied insects, such as aphids.

Flour paste.—Where syringing with water under pressure can not be practiced, infestations of red spiders may be held in check by spraying with flour paste composed of 1 pound of flour to 12½ gallons of water. Flour paste is mechanical in its action, in that it glues or sticks the mites to their food plant, thereby preventing further activities. The solution is easily prepared, but care must be taken not to burn the paste while heating. Two methods of preparation are suggested:

(1) Weigh out the proper amount of flour and add enough water to cover. Heat over a slow fire, or with live steam from jet, constantly stirring the mixture so as to break up the lumps and prevent scorching, until a thin sticky paste is formed; then add the full amount of water and strain through a fine-mesh screen or cloth into the spray tank. Keep agitated while spraying.

(2) To the proper amount of flour add sufficient boiling water to form a thin paste and stir until free of any lumps. Add the remainder of the water and strain into the tank as indicated above. Keep agitated while spraying.

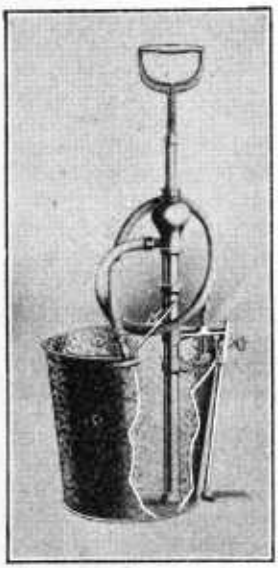

FIG. 3.—Bucket pump, suitable for spraying a few plants. (Quaintance and Siegler.)

Miscellaneous insecticides.—In addition to the above-mentioned preparations, lime-sulphur solution, linseed-oil emulsion, miscible oils, carbolic-acid emulsion, and sodium fluorid have been used to a limited extent in greenhouse insect warfare. Information on most of these sprays is given in Farmers' Bulletin 908.

SPRAYING AND DUSTING.

Promptness and thoroughness are prime considerations in the application of insecticides. The apparatus selected for spraying should be so constructed as to break up the liquid into a fine mistlike spray and insure an even coating over the plant surfaces. The integral parts of such an apparatus are the force pump, hose or tubing, and nozzles. Where only a very few plants are concerned, the hand atomizer is very convenient, but for commercial use the bucket pump (fig. 3) and the compressed-air sprayer (figs. 4 and 5) are suitable, the latter being preferable. Compressed-air sprayers have a capacity ranging from one-half gallon to 3 or 4 gallons, and are

very practical for bench work. For large commercial establishments, outfits with a capacity of from 5 to 25 gallons mounted on wheels (fig. 6) are most desirable, as they can be wheeled throughout the houses, and with some of them two leads of hose may be used at one time.

When purchasing equipment see that it is so constructed as to permit easy replacement of parts which are likely to wear out quickly, such as the valves. The spray hose should be about three-eighths to one-half inch in diameter and of the best high-pressure type. The length will naturally vary according to conditions, although the 25 to 50 foot lengths are very desirable. A hose reducer (fig. 7) attached to the end of a hose, with a cut-off coupled to the other end of the reducer, is very handy, since it serves to control or cut off the spray material whenever necessary and allows the further attachment of either a spray rod or a nozzle. A spray rod so attached will be found practical for spraying garden plants, or for plants in ground beds or on wide benches in the greenhouse, and for syringing in general. A convenient type of control for the end of the spray hose is shown in Figure 7.

FIG. 4.—One of several kinds of compressed-air sprayers on the market. (Chittenden.)

The nozzles should be preferably of the angled type and should deliver an even, cone-shaped spray. Two types of nozzles suitable for greenhouses and general spraying are illustrated in Figure 7. A straight nozzle may easily be converted to an angled type by using a 90° angle connection.

Several types of the modern hand dust guns are now being used by many florists where dusting is substituted for liquid spraying (fig. 8).

Other considerations for efficient control are the correct proportions of the ingredients in the preparation of the insecticide and the proper method of applying it. Disregard of these factors involves waste of material, possible injury to the plants, and questionable results. To get the maximum results the spray material should be directed to all parts of the plant by simple wrist movement from side to side, directing the spray up upon the under surfaces of the foliage as well as down upon the upper surfaces. An angle noz-

zle is very serviceable for such work. If one application is insufficient, repeat at intervals of a few days. Do not wait until serious damage has been wrought before resorting to spraying. Give careful attention to the selection of the insecticide to be employed.

FUMIGATION.

Fumigation is valuable for killing insects only when the plants treated are in an inclosed space, the object being to fill with poisonous gas the entire atmosphere in which the insects breathe. Greenhouses are admirably suited to such an operation. Tobacco extracts and hydrocyanic-acid gas are the fumigants commonly used for greenhouse fumigation, while carbon disulphid is one of the chief compounds employed for subterranean insects.

FIG. 5.—Compressed-air sprayer for general use in greenhouse and garden.

TOBACCO.

Tobacco fumigation is employed by florists for the control of plant-lice or aphids, thrips, and white flies, when it is not convenient to use hydrocyanic-acid gas. Tobacco stems have been used extensively in the past but have now been discarded because of the difficulty surrounding their use. At present the burning of standard tobacco papers or the painting of one or more hot steam pipes with the liquid or volatile extract is a very convenient and efficient method of producing a smudge. Especially prepared tobacco "meals," containing a definite amount of nicotine, have recently come into use for fumigating. Directions are usually given on the labels of the containers in which these materials are purchased. Attention is called to the fact that their active ingredients deteriorate with age, hence it is better to procure them several times during the year than to rely upon one large consignment.

HYDROCYANIC-ACID GAS.

Hydrocyanic-acid gas[3] is by far the most efficient and cheapest means of controlling thrips, plant-lice or aphids, white flies, and many kinds of scale insects, on ornamental plants grown under glass. It has not been generally adopted because of its poisonous nature, as

[3] See also Farmers' Bulletin 880, Fumigation of Ornamental Greenhouse Plants with Hydrocyanic-Acid Gas.

well as its disastrous effect on the tender plants if not properly used. Moreover, the prevailing impression is that fumigation with this gas is a cumbersome procedure and requires particular skill on the part of the operators.

In commercial practice hydrocyanic-acid gas is produced by the action of diluted sulphuric acid on a chemical salt containing cyanide, as sodium or potassium cyanide. In recent years sodium cyanide has superseded potassium cyanide for this purpose. The gas is colorless, and has the characteristic odor of peach pits.

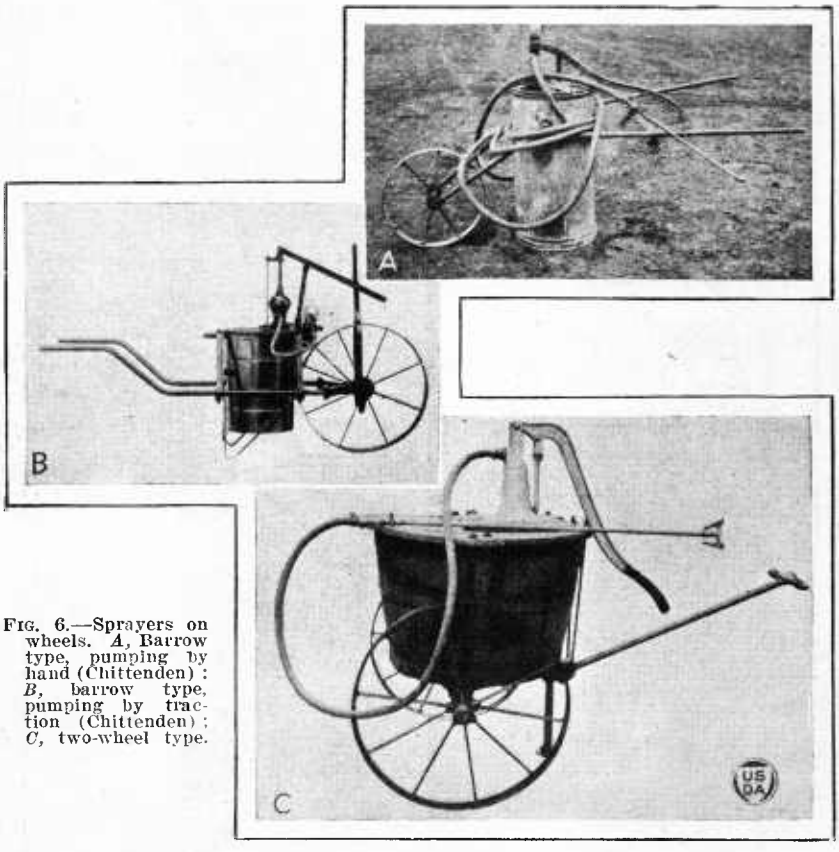

FIG. 6.—Sprayers on wheels. *A*, Barrow type, pumping by hand (Chittenden); *B*, barrow type, pumping by traction (Chittenden); *C*, two-wheel type.

Sodium cyanide (96 to 98 per cent) containing 50 to 52 per cent of cyanogen should be used. It may be purchased either in lumps or in the shape of an egg, each "egg" weighing, approximately, 1 ounce. **Sodium cyanide is one of the most deadly poisons known,** and should be stored in air-tight cans plainly labeled, and kept out of reach of those unacquainted with its poisonous nature.

Commercial sulphuric acid, with a specific gravity of about 1.84 (66° Baumé), or approximately 93 per cent pure, gives very satisfactory results. The acid should be kept in glass receptacles, properly labeled and tightly corked with a glass stopper. When handling the acid care should be exercised to prevent it from coming in con-

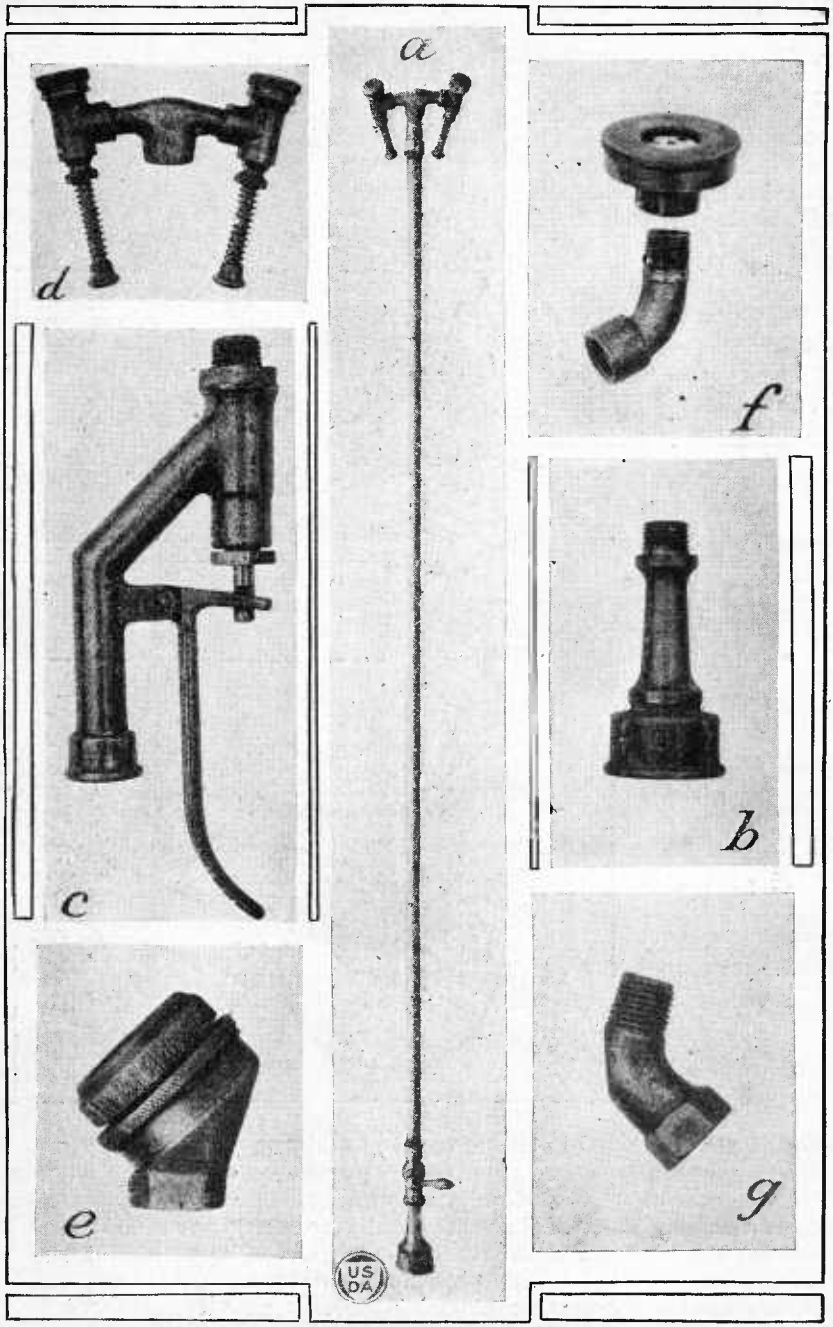

FIG. 7.—Spray nozzles and connections: *a*, Spray rod complete, showing female hose reducer, cut-off, brass spray rod, elbow, and cluster nozzles; *b*, female hose reducer; *c*, convenient type of control for end of spray hose; *d*, double spray nozzle; *e*, angled nozzle, whirlpool disk type; *f*, whirlpool type of disk nozzle and elbow (Quaintance and Siegler); *g*, 45° elbow.

tact with the clothing or skin. **Never pour the water on the acid**; always pour the acid on the water.

Greenhouse fumigation.—For greenhouse fumigation half-gallon or 1-gallon glazed earthenware jars are satisfactory generators. Jars with the inside rounded and constricted at the bottom are preferable, so that the cyanide will be entirely submerged in the acid and water, insuring the maximum generation of the gas. Correct scales or balances reading in tenths of ounces are desirable for accurate work, and an 8-ounce glass graduate is convenient for measuring the acid

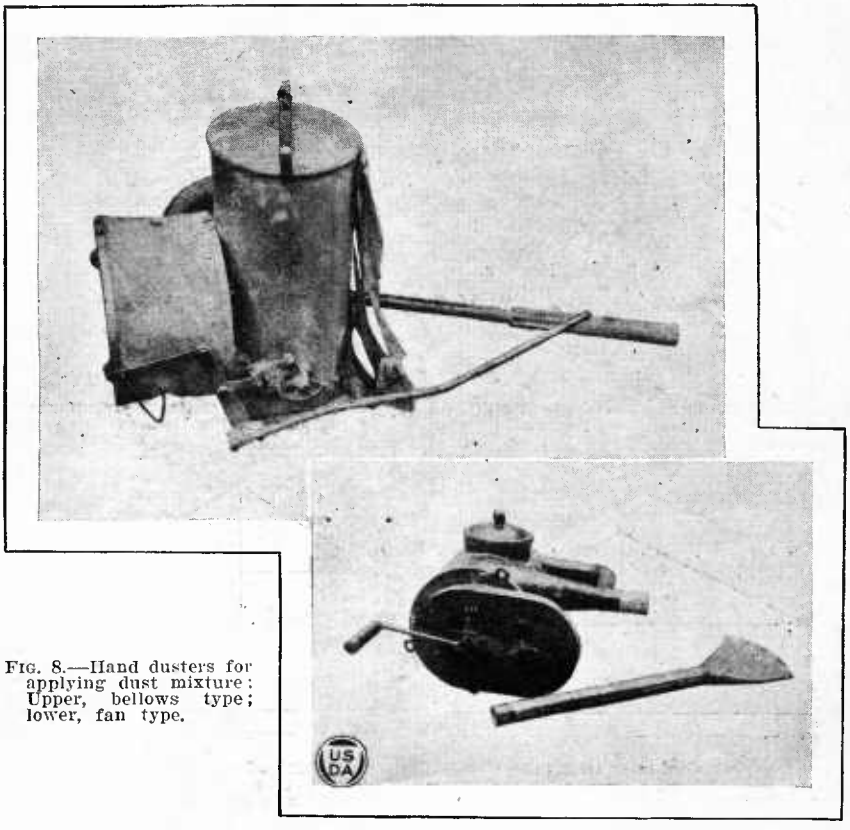

FIG. 8.—Hand dusters for applying dust mixture: Upper, bellows type; lower, fan type.

and water. A porcelain pitcher will be found very useful for drawing the acid from the carboy or original container.

It is well to use small paper bags or thin paper in which to place or wrap the cyanide. In preparing the greenhouse for the fumigation all broken glass should be replaced and the house made as nearly air-tight as possible. The ventilators should be so arranged, particularly those on the roof, as to permit their being opened from the outside (fig. 9) upon the completion of the exposure.

Before fumigation is undertaken it is imperative that the cubical contents of the house be accurately determined. The following is

an easy and satisfactory method of determining the cubical contents of the house:

To determine the cubical contents of an even-span greenhouse (fig. 10), compute the number of square feet in the rectangle *a* and in the right-angle triangles *b* and *c* and multiply the sum of the three by the length of the greenhouse.

For example: $a=5\times20=100$ square feet; $b=5\times10\div2=25$ square feet;[4] $c=5\times10\div2=25$ square feet; $a+b+c=150$ square feet; 150 square feet × 100 feet (length of house) = 15,000 cubic feet, the cubical contents of the greenhouse.

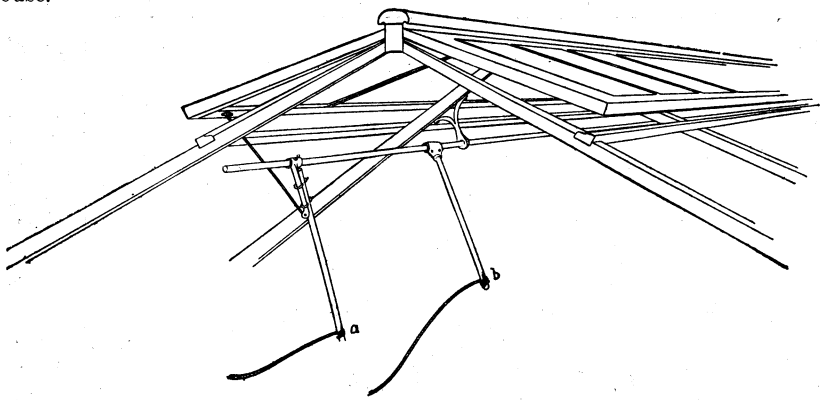

FIG. 9.—Methods of attaching rod and cord (*a*, *b*) to ventilator shaft of greenhouse so that the ventilators can be opened from the outside after fumigation. (Sasscer and Borden.)

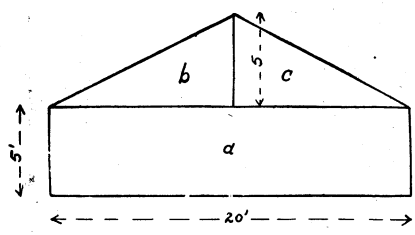

FIG. 10.—Method of computing cubical contents of even-span greenhouse. (Sasscer and Borden.)

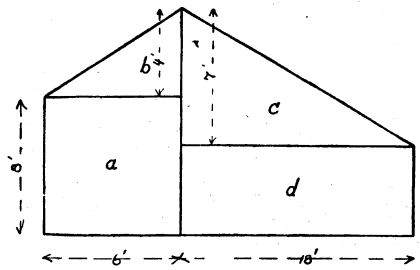

FIG. 11.—Method of computing cubical contents of three-quarter-span greenhouse. (Sasscer and Borden.)

To determine the cubical contents of the three-quarter-span greenhouse (fig. 11), multiply the sum of the rectangles *a* and *d* and the right-angle triangles *b* and *c* by the length of the house.

For example: $a=6\times8=48$ square feet; $d=18\times5=90$ square feet; $b=6\times4\div2=12$ square feet; $c=18\times7\div2=63$ square feet; $a+d+b+c=213$ square feet; 213 square feet × 100 feet (length of house) = 21,300 cubic feet, the cubical contents of the greenhouse.

In estimating the cubical contents of a greenhouse it is not necessary to make allowances for the space occupied by the elevated benches and pots.

[4] To calculate the area of a right-angle triangle, multiply the base by the perpendicular and divide the product by two.

To determine the total quantity of cyanide to be used, multiply the number of thousand cubic feet contained in the greenhouse by the quantity of cyanide to be used per 1,000 cubic feet; for example, if

FIG. 12.—Greenhouse ready for fumigation with hydrocyanic-acid gas. (Sasscer and Borden.)

one-half ounce cyanide is to be employed per 1,000 cubic feet, and the greenhouse contains 15,000 cubic feet, the total amount of cyanide necessary would be 7½ ounces.

The chemicals should be measured in the following manner: For each ounce avoirdupois of sodium cyanide use 1½ fluid ounces of sulphuric acid and 3 fluid ounces of water.[5]

Mixing the chemicals.—After the generators have been distributed throughout the house and before the chemicals have been mixed the cyanide should be weighed accurately and the proper quantity for each generator placed in a paper bag near the generator (fig. 12). The chemical should invariably be mixed in the following manner: First, measure and place in each generator the quantity of water required; second, measure and place in each generator the quantity of sulphuric acid required; third, drop the cyanide into the diluted warm acid in each generator and immediately leave the greenhouse; then close and lock the door and post a danger sign on it.

The cyanide, bag and all, should be dropped gently, not thrown into the generator, and the operator should begin at the generator farthest from the door and work toward the door. In case there are two rows of generators the cyanide should be dropped simultaneously by two operators. As little time as possible should elapse between the addition of the acid and the addition of the cyanide, as the heat which is liberated by the mixing of the acid and water assists in the generation of the gas.

The residue left in the generators after fumigation should be buried or poured into a sink and the generator washed before being stored for future operations.

The number of generators to be used will depend upon the size of the house, and they should be so arranged that the gas will be distributed uniformly throughout the inclosure, using preferably a greater number of jars spaced equal distances apart.

Fumigation of greenhouses with hydrocyanic-acid gas should not be undertaken in daylight under any circumstances, nor should it be done when the temperature of the house is below 55° F., or, in most instances, above 75° F., or when the wind is high, or on hot, humid nights when the extreme differences in temperature may prove disastrous to the plants. The exposure should not exceed one hour, after which the house should be thoroughly aired by raising the ventilators from the outside for a period of from 10 to 30 minutes, depending on the weather. If it becomes necessary to enter the greenhouse soon after ventilation, in order to determine the temperature, the person entering should not remain longer than is necessary. Never enter a greenhouse charged with the gas until it has been thoroughly aired. **One person should not attempt to fumigate a large greenhouse alone.**

Box fumigation.—Florists and nurserymen will find it very advantageous to have a fumigation box for the following occasions: (1) Preliminary tests to determine the quantity of gas that plants can withstand without injury in the several stages of growth; (2) to rid individual or potted plants of insects when an isolated infestation is discovered; or (3) when it is unnecessary to fumigate an entire house. Its use is almost indispensable for such plants as orchids,

[5] This is a slight deviation from the formula recommended for commercial operations. The additional water has been added in order to submerge the cyanide where small dosages are employed.

palms, aspidistra, and ferns and has an advantage in that it may be used in daytime, whereas house fumigation can be performed with safety after dark only.

Plants to be fumigated in a box in daytime should remain in the box with the door closed at least 1 hour before the gas is generated, and should be shaded from bright sunlight for at least 4 hours

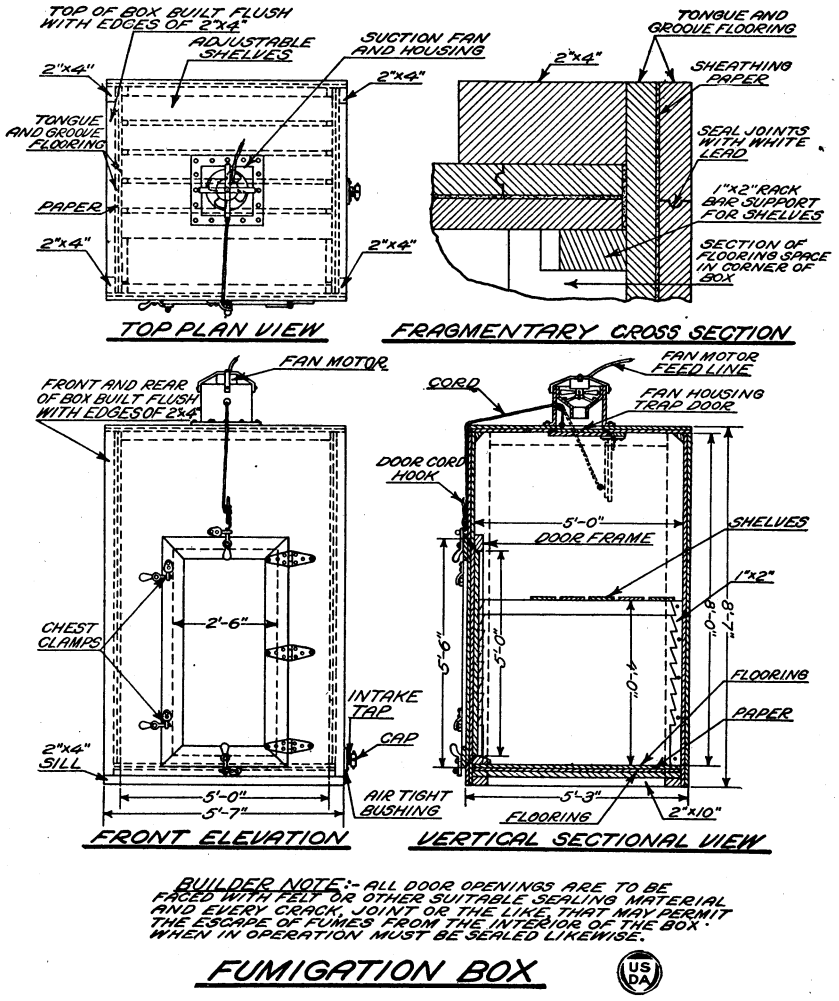

FIG. 13.—Plans of 200-cubic-foot fumigation box, showing details of construction.

after the completion of the exposure. For shading, a closely constructed slat house or potting shed is suitable.

The capacity of the box will naturally depend on the size of the establishment and the amount of fumigating to be done. Normally a box 5 feet square by 8 feet high, plans of which are given in Figure 13, is quite adequate for the average floral establishment.

For the framework use 2-inch by 4-inch material, and for the double walls, roof, and floor use 2-inch tongue-and-groove pine sheathing, or matched lumber, with heavy building paper or wall boarding between. The inside walls should run horizontally and the outside walls vertically. The door should be built in refrigerator fashion and swing on three heavy hinges, the edges closing against a felt or rubber seat. The same precautions should be taken for the casings of the ventilator in the roof in order to make it air-tight. Where the volume of business warrants it, the walls may be made of concrete or glazed hollow tile laid in cement. A secondary or slat floor about 1 foot from the bottom permits a better diffusion of the gas around the material to be fumigated. The suction fan referred to in the plans is not absolutely necessary except where the box is built within a commercial packing or shipping room in which many people may be working, or when time is a factor; otherwise the ordinary ventilator is sufficient opening to permit the escape of the gas.

Fumigation boxes should not remain exposed to the weather, as they will soon warp and become unfit for use. For this reason it is advisable also to keep doors and ventilators closed when the box is not in operation.

CARBON DISULPHID.

Carbon disulphid, while ordinarily used for killing insects in stored and manufactured products, also finds a limited use as a soil fumigant in the control of ants, root aphids, white grubs, and other soil-inhabiting insects. It is a clear, heavy liquid with a strong and disagreeable odor. On evaporation it gives off a gas about two and one-half times heavier than air, which diffuses throughout the soil. In applying carbon disulphid for soil insects, the liquid is distributed in one or two holes made about 4 inches from the base of the plant. One teaspoonful in each hole will suffice for smaller plants and a tablespoonful for larger ones. The holes must be immediately closed with earth by tamping the soil. **The fumes of carbon disulphid are explosive.** There must therefore be no smoking or carrying around of lights where carbon disulphid vapor is strong, and it is not safe to have steam pipes very hot, or to turn on or off an electric light. Even the heavy striking of a nail with a hammer might cause an explosion if the necessary density of carbon disulphid vapor were present.

SOME INJURIOUS INSECTS AND THEIR CONTROL.

For convenience the principal insect enemies of ornamental greenhouse plants are discussed under the plants which they attack, and for the sake of brevity essential facts only are given. In case a certain insect attacks two or more kinds of plants it is discussed under the one most severely affected.

AGERATUM.

Greenhouse white fly.[6]—This common and annoying insect infests many flowering and ornamental plants, particularly ageratum, calendula, primula, coleus, and geranium. In some instances these crops could hardly be grown without the aid of remedial measures. The depredations due to these insects are twofold: First, they suck up the plant juices, causing the leaves to become yellow and ultimately turn brown and die; secondly, the larvæ and pupæ excrete a "honeydew" liquid which gives the foliage a glazed appearance, and serves as a medium upon which a sooty fungus grows, ultimately affecting the commercial value of the plant. The mature four-winged white flies, which are scarcely longer than one-sixteenth of an inch, are covered with a substance which gives them a white floury appearance, from which they derive their name. The adult female flies live for a month or longer, and during this period feeding and egg laying are continuous. A single female is known to have laid 129 eggs. The minute eggs, which are generally laid on the under surface of the tender growth, hatch in from 10 to 12 days into flat, oval-shaped, light green larvæ, which crawl about to some extent but soon settle down and begin feeding, after which the legs become functionless. Within 13 to 18 days their full growth is attained, and after molting for the fourth time they enter the pupa stage, which requires from 12 to 16 days. Finally the fully developed adult flies (fig. 14) emerge, the cycle from egg deposition to emergence requiring approximately five weeks.

FIG. 14.—Greenhouse white fly, male and female. (Quaintance and Baker.)

Control.—The fact that it takes from 12 to 16 days to complete the pupa stage from which the adult flies emerge is taken advantage of in the control of this insect. Three or four successive fumigations with hydrocyanic-acid gas, using not over one-half ounce of sodium cyanide per 1,000 cubic feet of space, at intervals of approximately 10 days to 2 weeks, provide the most reliable and effective means of control. In this manner the several generations of adults are killed, preventing egg deposition for future generations.

If hydrocyanic-acid gas fumigation is not advisable, thorough spraying with fish-oil soap solution, or the 40 per cent nicotine solution, or nicotine oleate, may be employed, preferably preceded by one or two tobacco fumigations.

	See—
Red spider	Rose.
Leaf-tyer	Cineraria.
Cabbage looper	Calendula.
Yellow bear	Calendula.
Mealybugs	Coleus.
Plant-bugs	Sweet pea.

[6] *Trialeurodes vaporariorum* Westw.

ASPARAGUS AND OTHER "GREENS."

	See—
Leaf-tyer	Cineraria.
Cutworms	Carnation.
Aphids	Rose.
Red spiders	
Fuller's rose beetle	
Mealybugs	Coleus.
Oleander or ivy scale	Palms.
Bulb mites	Bulbs.
Sowbugs	Soil pests.
Other pests	Ferns.

BULBS.

The narcissus or daffodil fly.[7]—Like its companion, the lesser bulb fly,[8] the narcissus or daffodil fly has been repeatedly intercepted in bulb shipments received from Europe, and occasionally a large percentage of the consignment is infested, with resulting loss. Among the bulbs known to be hosts of this insect are the amaryllis, daffodil, hyacinth, narcissus, saltonia, tulip, and a few others. The maggots usually feed in the center of the bulb, and their presence is not readily detected unless the bulbs are handled, when they usually "give way" to the least pressure of the hand. Unlike the lesser bulb fly, however, only one maggot normally inhabits a bulb, although at times two or three may be found. Infested bulbs when cut open appear as represented in Figure 15.

This insect is one-brooded, passing the winter in the larva stage, within the bulbs, in the soil. Pupation takes place in the spring in the old burrow or in the soil near by. The adults appear in the early summer and deposit small, oval, white eggs on the plants near the base of the leaves, or in exposed portions of the bulbs. After eating their way through the tender scales they feed within the heart of the bulb and later hibernate. The legless maggots or larvæ are dirty-white or yellowish in color, and about three-quarters of an inch long, while the pupæ are elongate, grayish brown, and segmented. The adult flies are large, hairy, two-winged, black, usually banded with yellow or gray, and about one-half inch long, resembling a bumblebee in appearance.

Control.—Any prompt remedial measures resorted to will give only partial relief at the best. Infested bulbs are easily detected by their sickly and discolored appearance, and the fact that when pressed between the thumb and fingers, they "give way" on the least pressure. Obviously all such bulbs should be burned to forestall their subsequent reinfestation. If an attack is noted in the field the bulbs should be immediately taken out and burned and the topsoil deeply buried in September or early October. (See also "Control" under "Bulb mites.")

The lesser bulb fly.[9]—The economic status of this insect, which is also known as the lunate fly, or onion fly, is still in dispute. In view of its reputation as an onion pest in Europe, however, and recent records of its destruction of bulbs in this country, it may prove to be a real menace to florists and horticulturists. Its future activities,

[7] *Merodon equestris* Fab. [8] *Eumerus strigatus* Fallen. [9] *Eumerus strigatus* Fallen.

therefore, deserve close attention. Although it was first noted as occurring in the United States in 1906, it has since been reported to be established in California, Colorado, Maine, Ohio, New York, Texas, and Washington. Its host plants include amaryllis, onion, iris, hyacinth, shallot, and narcissus. Apparently narcissus seems to suffer most from its attack.

According to literature, the flies appear in May and June, and at this time lay their eggs on the bases of the leaves. The larvæ which hatch from these eggs in the nose of the bulb feed and work their way into the interior, causing it to become discolored, slimy, and decayed. As many as 77 larvæ have been found within a bulb (fig. 16). When full grown the maggots are from one-third to one-half inch long, dirty grayish yellow, and wrinkled. Pupation takes place

FIG. 15.—Bulb showing larva of narcissus or daffodil fly.

FIG. 16.—Bulb showing larvæ of the lesser bulb fly.

in the bulbs or in the surrounding soil during August, and it is believed that the larvæ which hibernate in the bulbs are those of a second generation, from which the adults or flies emerge the following spring. The fly has one pair of grayish wings, is about one-third of an inch long, and has a bronzy black abdomen marked with three white crescent-shaped bands, the tip being beset with yellowish hairs. They fly among the flowers of various plants and are usually out on bright sunny days.

Control is the same as for the preceding species.

Bulb mite.—It is safe to assume that a large percentage of all foreign bulbs are infested at the time they arrive in this country with one or more species of mites. Of these the more important are the "bulb mite"[10] and a closely related species.[11] The former has been found to attack narcissus, Easter lily, tulip, hyacinth, crocus, amaryl-

[10] *Rhizoglyphus hyacinthi* Boisd. [11] *Rhizoglyphus rhizophagus* Banks.

lis, dahlia, and orchid. Of these, narcissus and Easter lily suffer most severely and tulip and hyacinth to a less extent, owing to the apparent inability of the mites to penetrate readily the tightly overlapping scales.

Injury.—The mites burrow into the roots and stems of the bulbs (fig. 17) and cause reddish-brown spots on the bulb scales. After heavily infested bulbs are planted the new leaves soon become yellow,

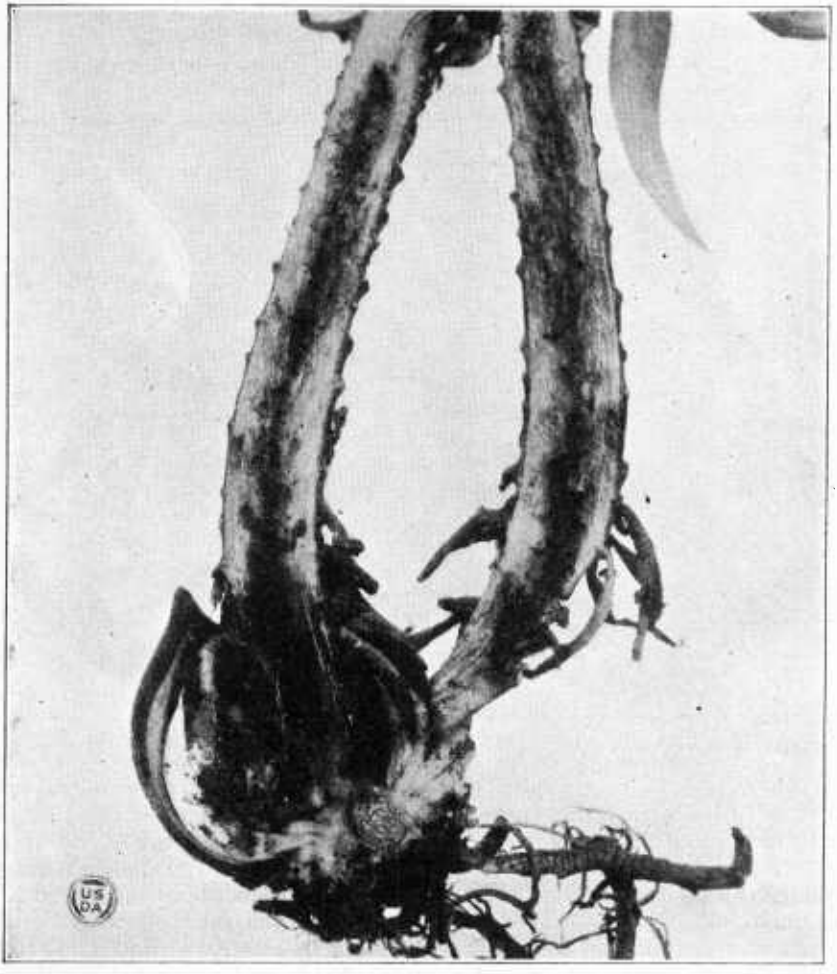

FIG. 17.—Lily bulb and stem split open to show injury by bulb mites.

growth is checked, and the flowers may fail to develop. In addition to the above injury, the mites are also believed to spread certain bacterial and fungous rots to healthy bulbs.

Although the mites are capable of living in diseased bulbs, there is much evidence to indicate that they prefer sound bulbs. Mites are frequently associated with decay in the bulbs, although feeding usually takes place in a healthy area beyond the decayed portion.

Life history.—The adult female deposits singly from 9 to 56 small white eggs beneath the scales of the bulb or on the tissue at the base of the bulb among the roots. As many as 130 eggs have been reported [12] as deposited by a single female. These eggs require from 1 to 10 days to hatch, depending on the temperature. The six-legged larvæ bore their way into the tissue and feed from one to three days, after which they become inactive or quiescent for one-half to two days, while the eight-legged nymph is forming within the larval shell. The nymph on emerging feeds from one to four days before passing into a quiescent stage, which lasts from one-half to three days. The adult then emerges, mates, and begins egg laying almost immediately.

Under certain conditions, such as lack of food, dryness, or the presence of predacious enemies, a new form, called hypopus, may develop between the nymphal stages. This is a small, brown creature, which is very resistant to unfavorable conditions, and is adapted for migrating to a fresh food supply by clinging to any moving object such as small flies or predacious mites. They may remain in the hypopal stage for several weeks before becoming nymphs and transforming to adult mites.

The normal life cycle, exclusive of the hypopal stage, may require from 9 to 27 days, so that under favorable conditions, such as are present in greenhouses, 10 or more generations may develop in a year. Female mites may live several weeks or months, but the males are usually shorter lived, dying in about 10 days or less.

Control.—Careful selection of the bulbs to be planted is the first consideration in escaping an infestation of mites. Observe also the following suggestions:

Burn all soft and rotten bulbs.

Use care in growing and fertilizing the plants.

Bulbs kept in cold storage should be held at about 35° F.

The most successful treatment for infested bulbs [13] is to immerse them for 10 minutes in a solution of 40 per cent nicotine sulphate at the rate of 1 to 400, heated to 122° F. The grower may also use nicotine oleate (p. 6) at the above temperature, hot water at 131° F. for 10 minutes, or a 2 per cent formalin solution heated to 122° F. for 10 minutes.

From the results obtained in recent experiments by W. B. Wood, of the Federal Horticultural Board, with "Sprekelia" bulbs, it seems justifiable to recommend treating them in hot water for 30 minutes at temperatures ranging from 122° to 124° F. In these experiments no injury followed, and the plants made the same growth as the untreated ones.

CALENDULA.

Cabbage looper.[14]—Although primarily an outdoor pest, the cabbage looper is a transient enemy of greenhouse-grown plants, feeding especially on the foliage and buds of carnation, chrysanthemum, cineraria, geranium, smilax, and German ivy. The injury is occasioned

[12] Garman, Philip. Bulletin 225 of the Connecticut State Agricultural Experiment Station, New Haven.

[13] See Bulletin 225 of the Connecticut State Agricultural Experiment Station, New Haven.

[14] *Autographa brassicae* Riley.

by the active green larva, which when full grown is about 1⅜ inches long, and bears a white stripe on each side of its body (fig. 18). As its common name suggests, it moves with looping movements after resting with the middle of the body elevated. Under greenhouse conditions it remains as a larva from two to four weeks and then changes to the pupa or chrysalis stage, within a silken cocoon attached to the leaves. The moth, which has grayish-brown forewings bearing U-shaped whitish markings, and lighter brown hind wings with darker scalloped margins, emerges from the cocoon in about a week during the summer months. The female moths deposit their convex pale green eggs, about the size of a mustard seed, singly on the upper surface of the leaf. These eggs hatch in from 4 to 10 days.

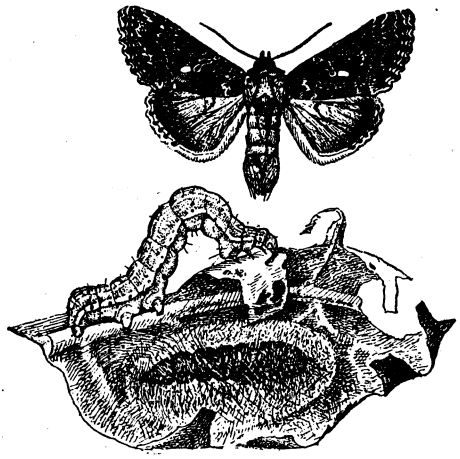

FIG. 18.—The cabbage looper. Above, male moth; below, full-grown larva in natural position feeding, and pupa in cocoon just before development of moth. Moth and larva about one-third larger than natural size; pupa more enlarged. (Chittenden.)

Control.—Remedies are the same as are recommended for the leaf-tyers under "Cineraria."

The "yellow bear." [15]—The yellow-bear caterpillar (fig. 19), one of the group known as "wooly-bear" caterpillars, frequently occurs in greenhouses, but fortunately for the florist it is less abundant than in the field, orchard, garden, and vineyard, and as it does not appear to prefer any particular greenhouse plant (except that in Canada it has been reported as injurious to chrysanthemum and marigold), its attack is usually so distributed that injury is not felt if careful watch is kept for the appearance of these larvæ so that they may be promptly destroyed.

Control.—Control is the same as for the leaf-tyer.

	See—
White fly	Ageratum.
Leaf-tyer	Cineraria.
Cutworms	Carnation.
Mealybugs	Coleus.
Plant-bugs	Sweet pea.
Blister beetles	Chrysanthemum.

CALLA LILY.

	See—
Aphids	Rose.
Red spider	Rose.
White fly	Ageratum.
Thrips	Carnation. Croton.
"Wooly-bear" and other caterpillars	Calendula.
Bulb mite	Bulbs.

[15] (*Spilosoma*) *Diacrisia virginica* Fab.

CARNATION.

Thrips.—Tender new growth, especially the buds and flowers of carnations and roses, is distorted by very small, active insects popularly known as thrips. Several species are involved, which frequently occur simultaneously and in sufficient numbers to destroy an entire crop of carnations. Unlike other insects, these little creatures possess mouth parts which are intermediate in structure between chewing and sucking types. They obtain their food by first rasping the tissues and then sucking the vital juices of the plant at the point of attack. Heavily infested plants are imperfectly developed and present a blotched, discolored appearance. Inasmuch as the various species commonly found on carnations and roses differ very little in their feeding habits and general structure, it will suffice

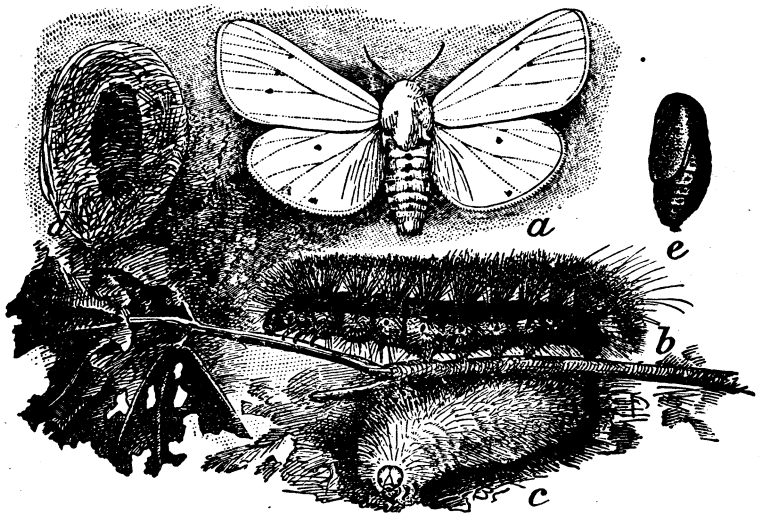

FIG. 19.—Yellow-bear caterpillar: *a*, Female moth; *b*, larva; *c*, pale form of larva; *d*, cocoon; *e*, pupa. (Chittenden.)

to refer only to the onion thrips,[16] which is the most injurious to carnations.

The adult onion thrips (fig. 20) is about one twenty-fifth of an inch long, pale lemon yellow in general color, exhibiting a blackish tinge, and possesses two pairs of minute wings which are featherlike in structure. The thrips are usually found on the outside of the bud or embedded within the petals of the flower, although the immature forms may occur within the partially unfurled flower buds. The microscopic, colorless eggs are deposited singly beneath the surface of the leaf tissue, and the young larvæ hatch in approximately four days, reaching maturity in about three weeks. The major injury under greenhouse conditions is done during the winter months.

Control.—The onion thrips may be controlled by one of the following methods: (1) Fumigation with hydrocyanic-acid gas at in-

[16] *Thrips tabaci* Lind.

tervals of eight days, using one-half ounce of sodium cyanide per 1,000 cubic feet of air space; (2) tobacco smudges produced from nicotine solution or preparations impregnated with it; (3) spraying with nicotine solutions; (4) dusting the foliage with either superfine tobacco dust or nicotine dust.

Cutworms.—Ornamental and flowering plants are frequently injured by cutworms, of which several species are known to occur in greenhouses. They are voracious feeders and on account of their nocturnal habits are rarely seen in the daytime except on cloudy days or in dark, secluded places. The so-called variegated cutworm [17] (fig. 21), which is an omnivorous feeder found in gardens, pastures, vineyards, and orchards, is the form which most frequently occurs in greenhouses. The larvæ are brought into the house with sod soil

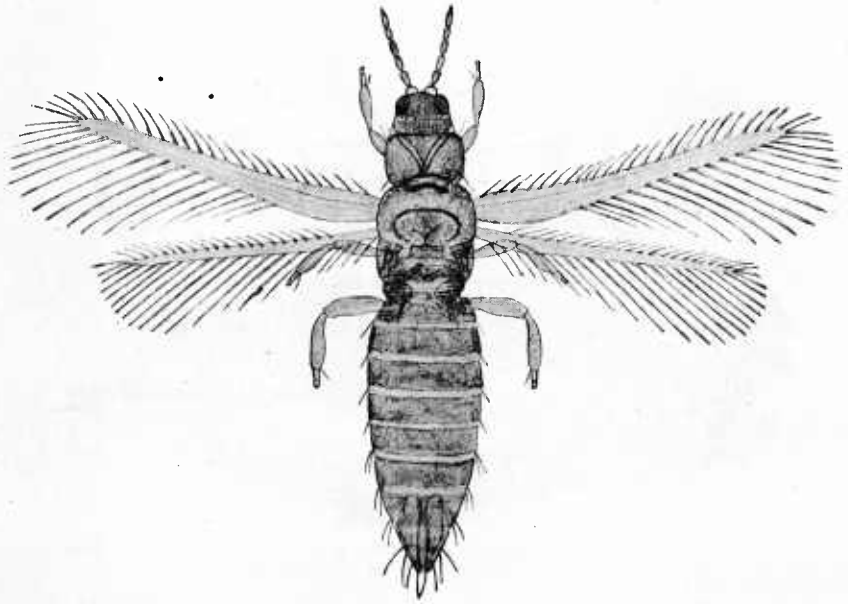

FIG. 20.—Adult of the onion thrips. Highly magnified. (Chittenden.)

when the beds are refilled, or the moths fly in through the ventilators. This cutworm is very destructive to the chrysanthemum, carnation, rose, sweet pea, asparagus, violet, and smilax. The larvæ not only cut off young plants near the surface of the soil, but they feed on the tender leaves of more advanced plants, and also devour the flower buds of carnations (fig. 22), chrysanthemums, and roses. Under greenhouse conditions all stages of this insect may be present throughout the year, although the principal injury usually occurs during the spring and summer months.

Owing to their nocturnal habits the larvæ are frequently not detected until they are present in sufficient numbers to cause serious injury in a comparatively short period. Obviously, therefore, it is very important to be constantly on the watch for these pests, and

[17] *Lycophotia margaritosa* Haw., formerly called *Peridroma saucia* Hbn.

as soon as discovered immediate steps should be taken to control them. After hatching from the egg, the larva becomes full grown in about four weeks and pupates in the soil, the pupal period lasting 15 to 20 days. The moth which issues from the pupa remains hidden during the day and flies at night, at which time the eggs are deposited. Each moth may lay as many as 300 to 500 eggs.

Control.—Poisoned-bran mash has given the best results in the control of the variegated cutworm. (See "Preparation of insecticides.")

Poisoned green bait, made up of lettuce leaves, sprinkled sparsely with Paris green or white arsenic, and placed at the base of the plants, may be substituted for plain bran mash.

Sterilize the soil with steam when refilling beds or benches. (See "Soil sterilization.")

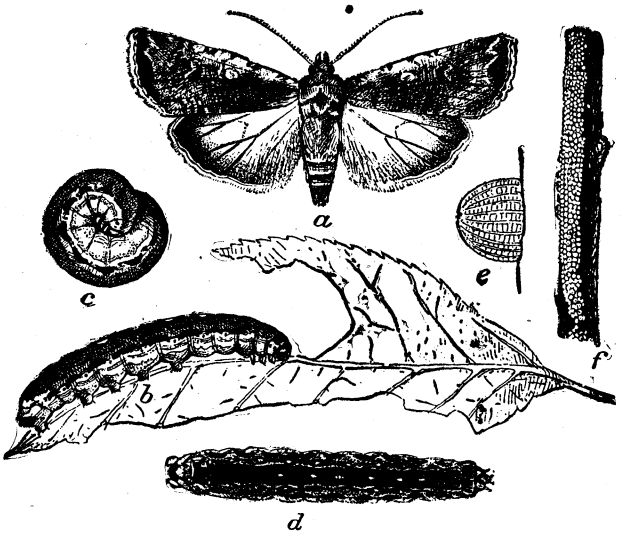

FIG. 21.—Variegated cutworm: *a*, Moth; *b*, normal form of caterpillar, side view; *c*, same in curved position; *d*, dark form, view of back; *e*, greatly enlarged egg, seen from side; *f*, egg mass on twig. (Howard.)

Spraying young plants with arsenate of lead offers reasonable protection.

Fumigation with hydrocyanic-acid gas, using three-fourths ounce to 1 ounce of sodium cyanide per 1,000 cubic feet of space, is an effective way to control the moths.

The mite [18] and the carnation bud-rot which accompanies it.—In the fall if carnation buds become deformed and fail to open, an examination may show that the interior is decayed and contains several glistening, whitish egglike bodies. This trouble is due to the carnation bud-rot, *Sporotrichum poae*, which is usually associated with the presence of a mite (fig. 23). The inner petal tips may appear as if fastened together in the center and top of the buds. The egglike bodies are those of female mites with their abdomens greatly distended, which are known to convey the fungus

[18] *Pediculopsis graminum* Reuter.

organisms from bud to bud. The same fungus and mite cause what is known as silvertop of June grass, and the two are always associated, as on carnations.

As it is prevalent only in fall, it is apparent that the disease and its conveyer (the mite) are brought into the house with the soil when the beds are replenished, which is usually late summer or early fall. As the new buds are formed they are soon attacked, and under the favorable conditions found in the greenhouse the mites multiply rapidly, so that by early November the infestation may be marked. The white varieties are more susceptible to the injury than the red and pink ones.

The female mite is very small when it enters the bud, but increases in size as it approaches maturity. The young hatch within the female's body and complete their development there. Finally, the abdominal sac disintegrates and the individuals are set free, after which they crawl to other buds. It is generally supposed they carry the bud-rot fungus spores with them, thereby spreading the disease as they migrate.

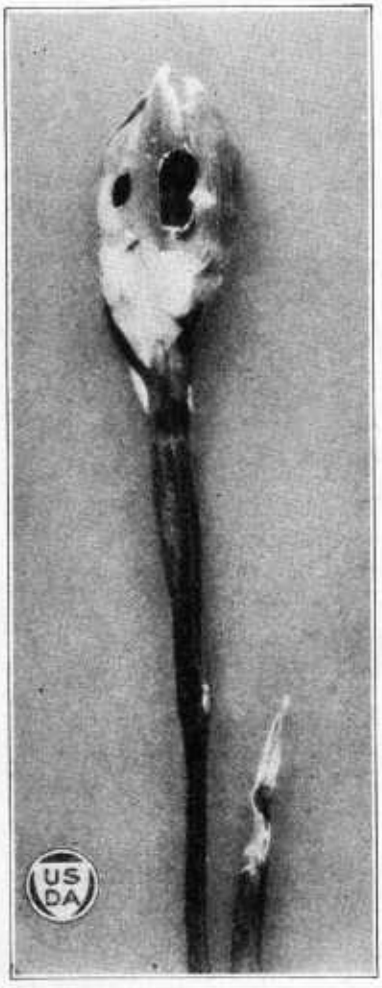

FIG. 22.—Carnation bud injured by cutworms.

FIG. 23.—Diseased carnation bud with mites. (Stewart and Hodgkiss.)

Control.—Gather and burn promptly all infested buds.

Red spider.—See "Rose." On carnation some growers claim that they control this pest by syringing with a weak salt solution. A

serious objection to the use of salt solution is that it causes the heating pipes and the ironwork of the supports and benches to rust out prematurely.

Aphids.—Several species of aphids occur on carnations, of which the green peach aphis[19] is most important (see "Rose aphids," p. 65).

	See—
Cabbage looper	Calendula.
The yellow bear and other caterpillars	
The greenhouse leaf-tyer	Cineraria.
Sowbugs on cuttings	Soil insects.
Plant-bugs	Sweet pea.
Corn earworm	Chrysanthemum.

CHRYSANTHEMUM PESTS.[20]

Chrysanthemum midge.[21]—The chrysanthemum midge is an imported enemy of the chrysanthemum, the seriousness of which is now well recognized. The injury is caused by the larvæ or maggots, which hatch from orange-colored eggs deposited on the surface of

FIG. 24.—Galls of midge on chrysanthemum leaf.

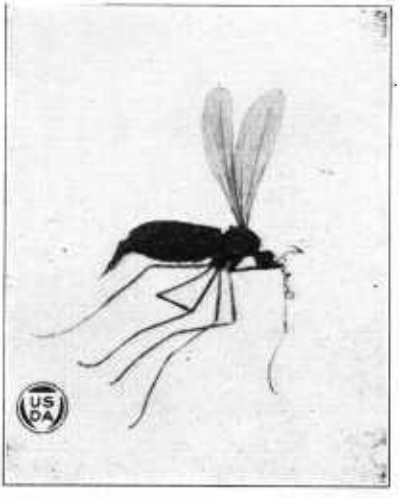

FIG. 25.—Adult female midge.

tender tips and new growth. The newly born larvæ bore into the plant tissue, where cone-shaped galls (fig. 24) are formed by the plant as a result of this irritation. When heavily infested the plants fail to bloom because of the dwarfed and gnarled condition of the growth. If the plants are attacked when the crown buds are forming, the flowers are not borne upright as normal flowers should be.

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[19] *Myzus persicae* Sulz.

[20] Detailed information on the more important insects that attack the chrysanthemum is given in Farmers' Bulletin 1306. In addition to the insects which are treated here, the following are treated in that bulletin:

The greenhouse leaf-tyer.	The variegated cutworm.	Ants.
The greenhouse white fly.	Scale insects:	White ants.
The common red-spider mite.	The greenhouse Orthezia.	Slugs and snails.
Plant-lice or aphids.	The hemispherical scale.	Sowbugs.
The greenhouse thrips.	Mealybugs.	Millipeds.

[21] *Diarthronomyia hypogaea* Löw.

The fully developed galls are about one-twelfth of an inch long and occur on the leaf, stem, or flower head of the plant, projecting obliquely from the surface. Both larvæ and pupæ complete their growth and development within the gall. When fully developed the pupa, still inclosed within the pupal skin, pushes itself out of the gall. The skin then splits down the middle of the back to allow the adult midge or fly to emerge, leaving the empty pupal skin protruding from the opening of the empty gall.

The adult midge (fig. 25) is a fragile two-winged fly about one-fourteenth of an inch long. The body of the male is yellowish orange, while that of the female is reddish orange. They emerge after midnight, and eggs which are laid in the early morning following hatch within 3 to 16 days, depending upon the temperature. It requires about 28 days from the time the larvæ first enter the tissues until the emergence of the adult, and the life cycle from deposition of the egg to emergence of the adult takes about 35 days. There may be six generations in a year, three in the spring months and three in the fall.

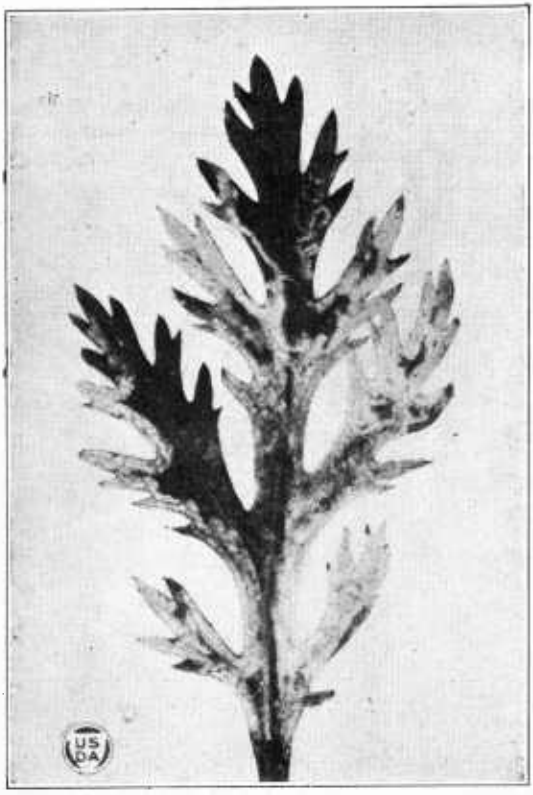

FIG. 26.—Daisy leaf showing injury by larvæ of the marguerite fly.

Control.—Nightly fumigation, continued from four to six weeks, with tobacco papers or with a weak dosage of hydrocyanic-acid gas, using one-eighth to one-fourth ounce of sodium cyanide per 1,000 cubic feet of space, is effective. Inasmuch as the adults do not leave the galls until after midnight, this work should be performed after that time. Spray every second or third day with nicotine solutions as directed on page 6 for a period of two or three weeks, depending upon the degree of infestation.

The marguerite fly,[22] or chrysanthemum leaf-miner, is capable of doing considerable damage in a comparatively short time if remedial measures are not adopted promptly. The injury (fig. 26) is occasioned by the larvæ or maggots mining within the leaf tissues,

[22] *Phytomyza chrysanthemi* Kowarz.

causing irregular white lines which extend over the entire leaf surfaces. This results ultimately in the death of a part of the leaf, and in time the whole leaf, with a checking of the normal development of the plant. Commercial growing of marguerites has been discontinued in several localities, owing to the depredations of this insect.

The adult insect is a small grayish fly only about one-twelfth of an inch long, and lays its eggs singly within the leaf tissue. These hatch in about 5 days into larvæ, which feed on the cells directly below the upper leaf surface. In about 18 days they pupate within the mine, and from 13 to 15 days later emerge as flies (fig. 27). The cycle from oviposition to emergence requires from 23 to 30 days, depending upon the temperature maintained in the house.

FIG. 27.—Female of marguerite fly.

Control.—Spray with nicotine sulphate, or free nicotine (1 to 500), or nicotine oleate, at intervals of 10 to 12 days.

Burdock leaf-miner.[23]—Injury to chrysanthemum leaves by the burdock leaf-miner is illustrated in Figure 28, and the adult is

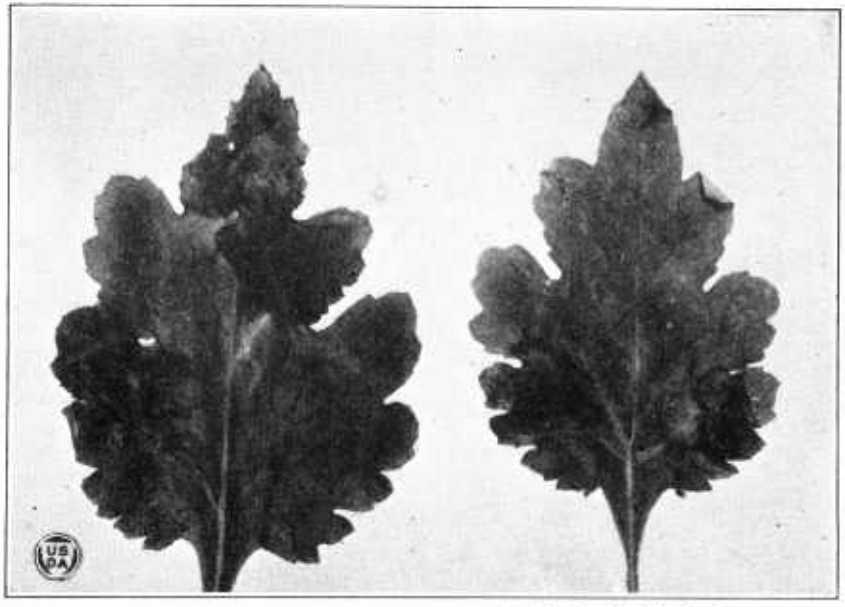

FIG. 28.—Injury to chrysanthemum leaves by the burdock leaf-miner.

shown in Figure 29. While primarily a pest of burdock, it has recently been extremely destructive to chrysanthemums under glass, and destroys entire lots of plants where the infestation occurs. Very little is known of the life history of this insect.

Control is the same as for the marguerite fly.

[23] *Agromyza maculosa* Malloch.

The corn earworm.[24]—In the fall the corn earworm, which normally feeds on corn and tomatoes, sometimes invades greenhouses, where it shows a marked preference for the buds and flowers of such plants as chrysanthemum, carnation, rose, and geranium. The larvæ are from one-sixteenth of an inch to $1\frac{1}{2}$ inches long, and the color may change from reddish-brown to green, with brown, black, or green stripes, or indistinct markings, as they mature.

FIG. 29.—Adult of the burdock leaf-miner.

According to Dietz,[25] the newly hatched caterpillars, before their presence was discovered, destroyed from 40 to 90 per cent of the buds of a certain variety of chrysanthemum which had been "taken." In the case of roses the injury was similar to that of the rose budworm, and 10 to 15 per cent of the buds were injured. In carnations 15 to 25 per cent of the buds were badly damaged by the larger caterpillars, and in some cases the crowns of the plants were also severely injured. The stalks of geranium stock plants in the field were tunneled and some of the plants ruined.

Control.—Directions for control are the same as for the greenhouse leaf-tyer, under "Cineraria."

Blister beetles.—Blister beetles (fig. 30) are rather large, slender in form, and somewhat soft-bodied. Different species are colored

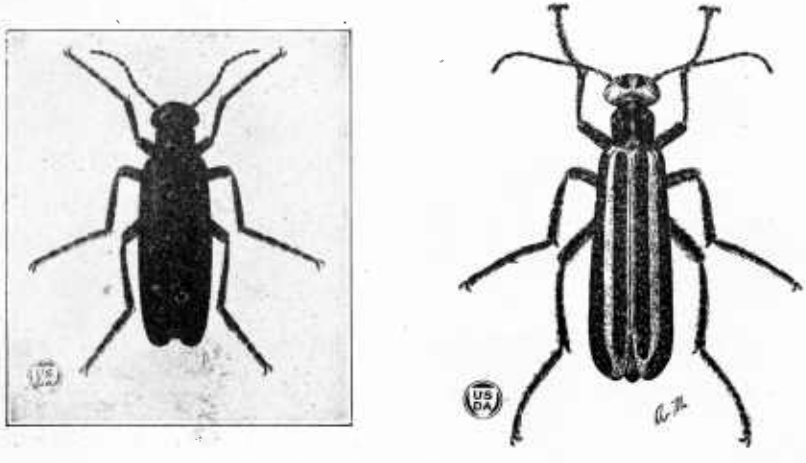

FIG. 30.—Adult of the black aster beetle, left, and of the striped blister beetle, right.

variously, as the following common names indicate: Black aster beetle,[26] striped blister beetle,[27] gray blister beetle,[28] margined blister

[24] *Heliothis obsoleta* Fab.
[25] Dietz, Harry F. Greenhouse inspection in Indiana. *In* Indiana, Department of Conservation, Report of Division of Entomology and List of Nurserymen for 1921, pp. 8–15, 1922.
[26] *Epicauta pennsylvanica* DeG.
[27] *Epicauta vittata* Fab.
[28] *Epicauta cinerea* Forst.

beetle,[29] and ash-gray blister beetle.[30] They are called blister beetles because contact with them may produce blisters on the human skin.

The beetles, which emerge in the spring, are voracious feeders, and the black aster beetle, especially, is destructive to chrysanthemums and asters. Although primarily an outside pest, it is known also to attack and feed on the following greenhouse plants: Calendula, dahlia, gladiolus, carnation, and verbena. In the younger stages the larvæ feed in the egg clusters of grasshoppers in the soil and are usually regarded as beneficial.

Control.—Blister beetles may be poisoned by prompt and thorough application of arsenicals such as arsenate of lead or Paris green. Where only a few plants are concerned, hand picking is effective, but gloves should be worn or the hands may be blistered by contact with the beetles. Plants may be protected by covering with mosquito netting where practicable.

European corn borer.[31]—Since 1917, when the European corn borer was first discovered in Massachusetts, where it had probably been introduced from Europe, it has become a very serious pest. Although corn is its favorite food plant, it is by no means restricted to that crop. It inflicts serious damage on such commercially important plants as gladiolus, cosmos, dahlia, hollyhock, chrysanthemum, and aster. The injury to greenhouse chrysanthemums, which has been observed recently by the writers, is especially severe since the tunnels (fig. 31) made by the larvæ in the stalks and flower stems cause them to wilt and frequently to break at the point of entrance. In the case of roses they destroy the buds by feeding in them. Geraniums and other thick-stemmed flowering plants are not immune from their ravages.

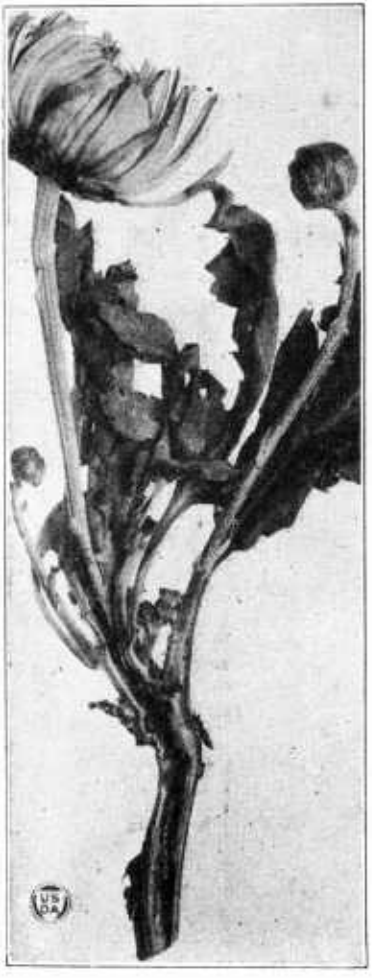

FIG. 31.—Chrysanthemum, with caterpillar of the European corn borer within the stem at lower end. (Walton.)

Control.—Burn all plants or portions of plants containing caterpillars. Since the borer lives over winter in the stalks of various weeds, as well as corn, all stubble and weeds surrounding the greenhouse should be destroyed by burning or deep plowing. Screen all openings to keep out the moths.

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[29] *Epicauta marginata* Fab.
[30] *Macrobasis unicolor* Kby.
[31] *Pyrausta nubilalis* Hübn. For a more complete account of this insect see Farmers' Bulletin 1294.

CINERARIA.

Greenhouse leaf-tyer.[32]—The greenhouse or celery leaf-tyer, as it is referred to on outdoor plants, has attracted considerable notice during recent years owing to the serious injury which it has caused on cineraria, chrysanthemum, and snapdragon, resulting in some instances in complete destruction of the plants attacked. The larvæ

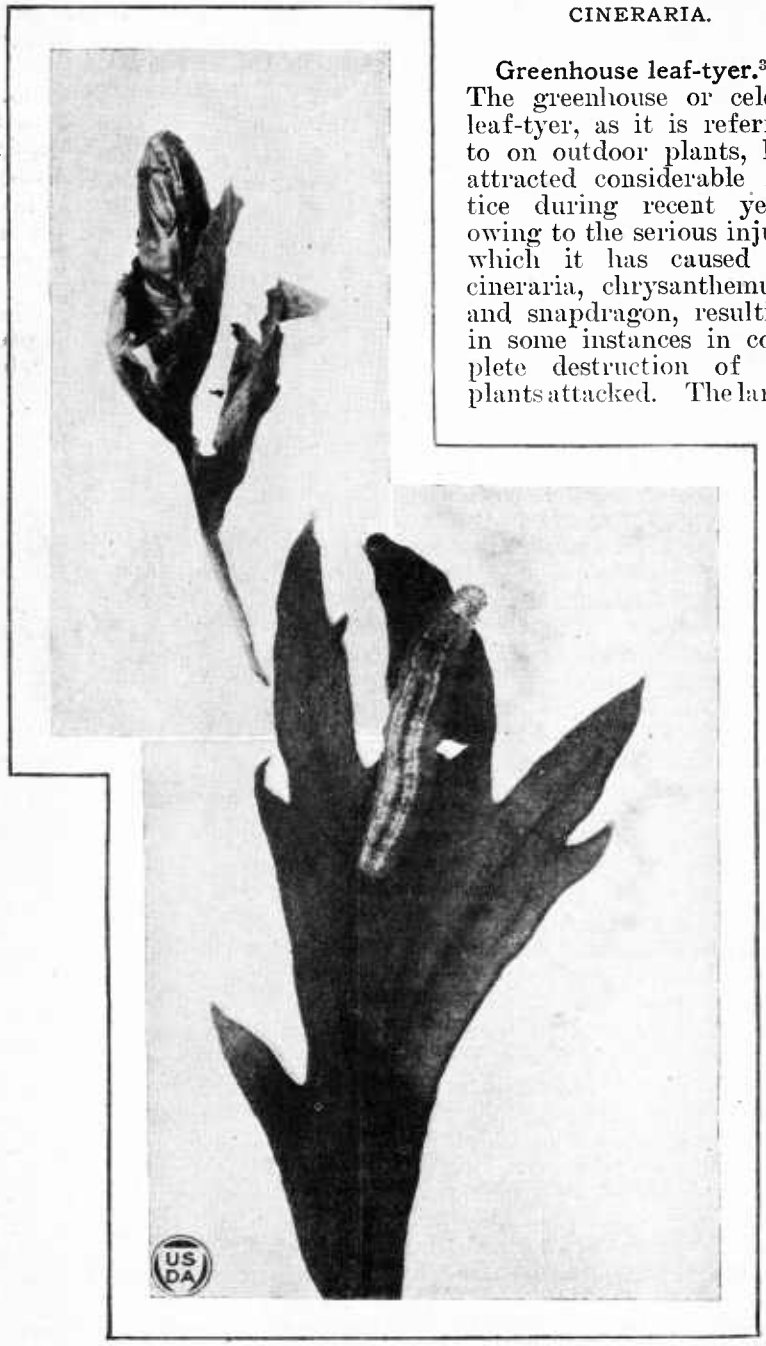

FIG. 32.—Larva and pupa of the greenhouse leaf-tyer. Greatly enlarged.

[32] *Phlyctaenia rubigalis* Guen.

or caterpillars feed almost entirely on the underside of the foliage, eating away the soft tissue, usually leaving the top surface intact, although they may devour the entire tissue in the areas where they feed. Close examination will reveal them feeding within lightly woven silken webs or between the surfaces of the edge of a single leaf folded over or between two or more contiguous leaves tied together. As a result the infested plant is greatly weakened, and the market value is greatly diminished because of the disfigurement of the leaves.

The eggs, which hatch in from 5 to 12 days, are laid for the most part on the underside of the leaf in masses which are easily recognized in the bright sunlight by their iridescent appearance. The caterpillars which hatch from these eggs are about three-fourths of an inch long when full grown, greenish, and marked with longitudinal stripes (fig. 32). When ready to pupate the caterpillar folds over a portion of the leaf on which it is feeding, often forming a slight cocoon, and pupates within. The pupa (fig. 32), which is characterized by its chocolate-brown color, requires about 10 or 12 days to transform to the parent moth.

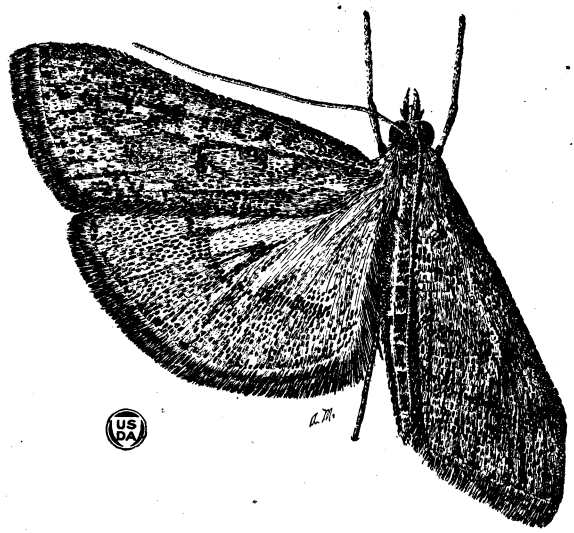

FIG. 33.—Moth of greenhouse leaf-tyer. Greatly enlarged.

The moth (fig. 33) has a wing expanse of three-fourths of an inch, is of a pale brown or rusty brown color, marked crosswise with darker lines, and when at rest assumes a characteristic triangular shape measuring three-eighths of an inch at the widest part. During the day the moths are very quiet and are found resting on the undersides of leaves, under the benches, or in other sheltered places in the greenhouse. After dusk they become very active, and the slightest disturbance will cause them to take to flight. It requires from 36 to 43 days to complete the development from egg to adult, and under greenhouse conditions there may be eight or more generations annually.

Control.—Since the larvæ are more easily detected when the plants are small, a serious infestation may be prevented by destroying all found at that time. If a limited number of larvæ are present, hand picking may prove effective and practical, but should be followed by the use of one of the following insecticides. For the control of the young caterpillars, young plants may be dipped in a solution of arsenate of lead or Paris green, or the plants may be dusted with a dry mixture of superfine sulphur, 9 parts, with 1 part of calcium arsenate, or arsenate of lead.

The adults can be controlled by fumigation with hydrocyanic-acid gas at night, using 1 ounce of sodium cyanide per 1,000 cubic feet of space.

	See—
Loopers and caterpillars	Calendula.
Cutworms	Carnation.
White fly	Ageratum.
Mealybugs	Coleus.
Red spider	Rose.

COLEUS.

Mealybugs.—The common [33] and long-tailed [34] mealybugs may be distinguished by referring to Figure 34. They are both about one-

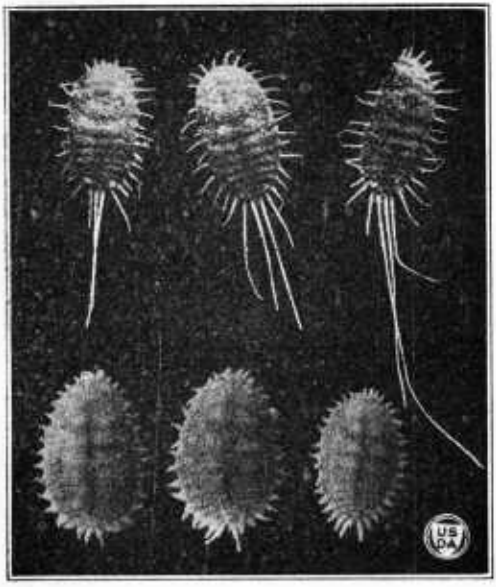

FIG. 34.—Mealybugs: Upper, long-tailed mealybug; lower, common mealybug.

FIG. 35.—Portion of coleus plant infested with common mealybugs.

fifth of an inch long, soft in texture, segmented, and covered with a mealy secretion. As its name implies, the long-tailed mealybug possesses long tail filaments which are absent in the common mealybug. Both have a wide distribution. The common mealybug is well known to every greenhouse propagator and infests so many species of plants that it would be much easier to list those not infested (fig. 35).

Control.—Syringe with clear water under strong pressure in the same manner as recommended for the red spider.

Spray frequently, using whale-oil soap or soap solution, or nicotine oleate, or kerosene nicotine oleate, or other nicotine solutions.

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[33] *Pseudococcus citri* Risso. [34] *Pseudococcus adonidum* L.

Fumigate several times at weekly intervals, using from 1 to 1½ ounces of sodium cyanide per 1,000 cubic feet of space, which will operate against immature forms.

Since ants are in most part responsible for the dissemination of mealybugs from plant to plant, their destruction is of prime importance in controlling mealybugs, for which purpose ant poison (p. 72) should be placed about the greenhouses.

The greenhouse Orthezia.[35]—The greenhouse Orthezia is a scale insect which infests more than 125 varieties of bedding plants, being especially abundant on coleus, lantana, ageratum, chrysanthemum, and amaranth. It is frequently referred to in tropical countries as the lantana bug because of its predilection for that plant. The fully developed female (fig. 36) presents a rather striking appearance, with its fluted white ovisac and marginal fringe of white plates. The adults move about from place to place on the plants and are frequently responsible for serious injury to numerous bedding plants.

FIG. 36.—Portion of coleus plant infested with greenhouse Orthezia.

Control.—Fumigate with hydrocyanic-acid gas, using two-thirds of an ounce of sodium cyanide per 1,000 cubic feet of space, three times at weekly intervals, or use the same spray solutions as are recommended for mealybugs.

	See—
White fly	Ageratum.
Plant-bugs	Sweet pea.
Sowbugs on cuttings	Soil insects.

CROTON.

The greenhouse thrips.[36]—Serious injury to croton, chrysanthemum, and many other ornamental plants is caused by minute, slender, active insects known as thrips, which obtain their food primarily by rasping the foliage and sucking the juices, although other portions of the plant than the foliage are not immune from their attacks. Their feeding leaves white spots at points of attack. As feeding continues these coalesce, forming blotches, and ultimately causing a wilting and drooping of the foliage. Like white flies and aphids, thrips secrete a reddish fluid which later turns black, giving the plant an unsightly appearance. This reduces the commercial value of the plant, because the color and beauty of the foliage are spoiled.

The adult (fig. 37) is microscopic in size, being about one twenty-fourth of an inch long. It is dark brown in general color and is

[35] *Orthezia insignis* Dougl. [36] *Heliothrips haemorrhoidalis* Bouché.

provided with two pairs of featherlike wings. The tip of the body is much lighter in color. The eggs are laid singly in an incision made in the leaf tissue by the adult female, generally on the underside. From these eggs hatch minute, almost colorless larvæ in from 4 to 8 days after deposition, but soon after feeding begins they become reddish. During the period of growth, which requires from 10 to 20 days, these larvæ feed actively in colonies, causing the same type of injury as is done by the adults. When full grown the larva enters the pupa stage, during which no food is taken. After 4 or 5 days the fully developed adult thrips emerges. Under greenhouse temperatures a generation is completed in from 20 to 33 days, and many generations occur throughout the year.

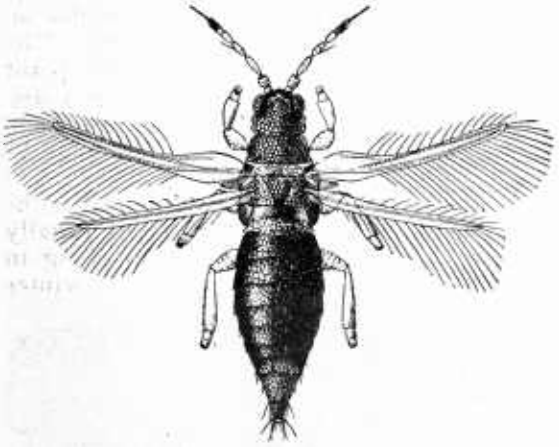

FIG. 37.—Adult of greenhouse thrips. (Russell.)

Control.—One of the following control measures may be employed: (1) Fumigation with hydrocyanic-acid gas, using one-fourth to one-half ounce of sodium cyanide per 1,000 cubic feet of space; (2) tobacco smudges from the liquid extract or paper impregnated with it; (3) spraying with contact insecticides, as Paris green and brown sugar; or (4) dusting the foliage with superfine tobacco dust or nicotine dust.

Long soft scale.[37]—In general appearance this species (fig. 38) is very similar to the soft brown scale, except that it is somewhat longer and usually more convex.

Control.—Control is the same as for the soft brown scale. (See "Ferns.")

Other scale insects which are likely to occur on croton are treated under ferns, palms, and orchids.

Mealybugs..... See Coleus.

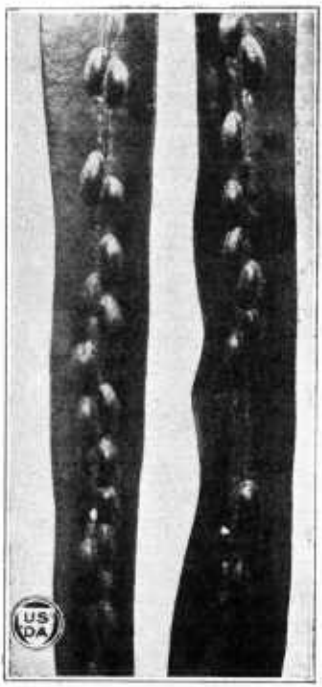

FIG. 38.—Long soft scale.

CYCLAMEN.

Cyclamen mite.[38]—The cyclamen mite, occasionally referred to as the "pallid mite," probably occurs throughout the United States wherever cyclamen stock is grown, and the injury resulting from its attack

[37] *Coccus elongatus* Sign. [38] *Tarsonemus pallidus* Banks.

is responsible for the loss of large sums annually. In addition to cyclamen, this pest attacks snapdragon, geranium, begonia, fuchsia, and chrysanthemum. The mite for the most part confines its injury to the young leaves, and the gall-like appearances visible on older leaves are evidently produced while the plants are small. The mite pierces the tissues and sucks the liquid contents of the plant cells, causing small brown specks and eventually producing a distorted, dwarfed, and shriveled plant (fig. 39). When the flowers and leaf buds are attacked they become streaked, and wither and die prematurely.

The adult mite is very minute and glassy in appearance. The ellipsoidal eggs are extremely small and pearl-like, and are usually deposited at night in protected places on the foliage, hatching in from 7 to 11 days. Most of the egg laying occurs during the winter

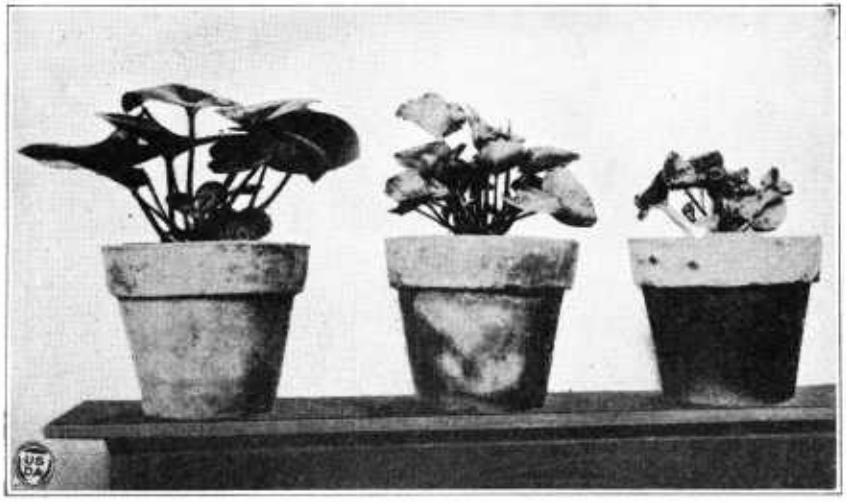

FIG. 39.—Work of cyclamen mite: Left to right, a healthy, a somewhat infested, and a badly infested cyclamen plant with the characteristic distortion, dwarfing, and curling of the foliage. (Moznette.)

months, from November to March. From these eggs hatch small, active, and glistening larvæ, having three pairs of legs. The larval stage is divided into an active and a quiescent period, the former requiring about 7 days, while the latter takes about 3½ days, after which the fully developed eight-legged adult mite is produced, which may live from 14 to 20 days. The life cycle from egg to adult requires from 4½ to 6 weeks. All stages may be found at any time during the year in greenhouses, although the greatest destruction is wrought during the winter months.

Control.—As in the case of the common greenhouse red spider, fumigation is not effective against these creatures; hence sprays must be used for control measures, rather than fumigation. Spray or dip the plants every 10 days after they have reached a height of 1½ inches with nicotine solution 1 to 800 (p. 6), or nicotine oleate. When older plants have become infested there is not much hope of saving them. They should be promptly removed and burned, and the soil in which they have been growing sterilized.

Sowbugs.—Young plants are attacked at times by sowbugs, millipeds, etc. (See " Soil insects.")

	See—
Greenhouse leaf-tyer	Cineraria.
Greenhouse thrips	Croton.
Aphids	Rose.
Black vine weevil or cyclamen weevil	Ferns.
Soil insects	Soil insects.

FERNS.

The Florida fern caterpillar,[39] which is native to tropical America, has in recent years been introduced into northern greenhouses on

FIG. 40.—Florida fern caterpillar: Moth above; striped larva at left; dark larva at right. Enlarged. (Chittenden.)

infested plants from Florida. It apparently restricts its attack to ferns, chiefly Nephrolepis and Adiantum, and has been reported in greenhouses in the District of Columbia, Illinois, Indiana, New York, and Ohio. The caterpillars, which feed chiefly at night or on cloudy days, attack the new growth, cut the tip of the tender midrib, and strip the leaflets from the remaining stem. During the day they usually conceal themselves in the crown of the plant, along the underside of the midrib of the frond, or even in the soil. The maximum injury usually is inflicted in May and late fall, although the caterpillars may be found throughout the year.

[39] *Callopistria floridensis* Guen.

The adult is about one-half inch long and has a wing expanse of about 1⅛ inches. The forewings are pale brown and present an attractive pattern, as shown in Figure 40. The eggs, which are slightly flattened, heavily ribbed, and light yellowish green, are laid singly on the underside of the tender leaflets. The caterpillars reach maturity in about two weeks. When full grown, two types are usually present, one a pale green and the other a velvety black. Pupation usually takes place underground within an oval cocoon composed of silken threads, although occasionally pupæ are found on the benches. The moth appears from the cocoon in about two weeks.

Control.—Often light infestations may be controlled by simple hand picking of the caterpillars at night with the aid of a light or by removing them from the soil at the base of the plant in the daytime. This method, alone, however, is not sufficient and should be accompanied by the use of trap lights or poisoned bait.

Dusting with pyrethrum powder gives good results, provided it is done consistently, but dusting necessitates a waste of material compared with the application of the powder in suspension. There is no danger of injury from the latter, and it is important to keep the plants well protected with the spray.

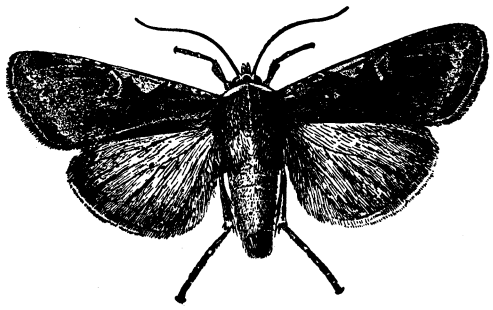

FIG. 41.—Moth of the spotted cutworm. (Walton.)

Lead arsenate-lime solution is another spray which may be used effectively and which can be washed off by thoroughly syringing with water before the plants are removed from the greenhouse. This solution is prepared in the same manner as arsenate of lead, excepting that from 2 to 4 pounds of lime are added, the lime and powdered arsenate of lead being made up as a paste prior to adding the 50 gallons of water.

Fumigation with hydrocyanic-acid gas, using three-fourths of an ounce of sodium cyanide per 1,000 cubic feet of space, can be employed for Adiantum and Nephrolepis ferns. Florists' greens, including smilax and *Asparagus plumosus*, however, are susceptible to injury at a much lower dosage and should not be subjected to the gas in a house containing miscellaneous ferns, but should be removed from the house before fumigating.

Cutworms.—Two species of cutworms have been found attacking ferns, the spotted cutworm [40] (fig. 41), and the variegated cutworm [41] (fig. 21).

Control.—Use poisoned-bran mash, poisoned green bait, trap lights, fumigation, and spraying, as recommended under control of cutworms on carnations.

Weevils.—The black vine weevil,[42] also known among florists as the cyclamen grub or weevil, and the pitchy-legged or clay-colored

[40] *Agrotis c-nigrum* L.
[41] *Lycophotia margaritosa* Haw.
[42] (*Otiorhynchus*) *Brachyrhinus sulcatus* Fab.

weevil [43] are recorded as feeding on ferns. These weevils were undoubtedly introduced into this country in soil around imported plants. The black vine weevil (fig. 42), which is about three-eighths of an inch long and black, has been recorded as attacking ferns, cyclamen, primrose, palms, geranium, gloxinia, and other plants. The clay-colored weevil, which is a trifle smaller and dark brown, has been taken feeding on ferns in Massachusetts. During the winter months the larvæ (fig. 43) feed on the young roots, and the adults, which appear in April and May, feed at night on the edge of the fronds.

FIG. 42.—Adult of black vine weevil.

Control.—The nocturnal feeding habit of these insects suggests shaking them off the plants at night, when they may be collected and destroyed. Trapping them under boards or chips during the day is recommended.

Spraying with arsenate of lead or dusting with the dry mixture should prove effective against the adults.

Injecting carbon disulphid into the soil would undoubtedly prove effective against the larvæ and pupæ.

Felt [44] suggests that since the adults feed on a variety of plants, and since they are wingless and must crawl from one to another before depositing eggs which develop into destructive larvæ, it should be comparatively easy to prevent injury to annual potted plants by making it impossible for crawling insects to get from infested permanent plants to the others. In the case of these weevils bands of sticky tree-banding material should prove effective barriers, as they have against various crawling insects, and it should not be difficult to protect younger plants in individual beds or series of beds with this material. Boards 1 inch thick and 6 inches high, in length and width to fit the benches or beds, could be fastened together at the ends, the framework placed an inch or so in the soil and the upper outside edge covered with sticky material to prevent

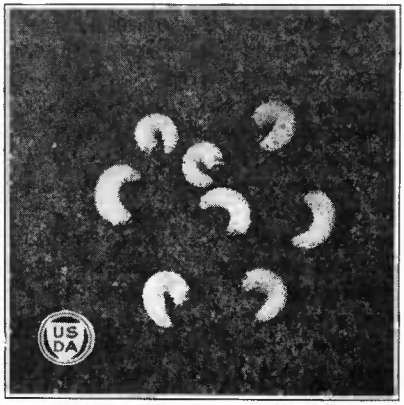

FIG. 43.—Larvæ of the black vine weevil.

[43] (*Otiorhynchus*) *Brachyrhinus singularis* L.

[44] Felt, E. P. Thirty-third report of the New York State entomologist, 1917. New York State Museum Bulletin 202, p. 59. 1917.

the weevils from gaining access to the inclosure containing the plants. To protect clothing, a strip of thin wood 2 inches wide could be nailed to the top of the framework, projecting above it.

	See—
Fuller's rose beetle [45]	Rose.
The greenhouse thrips	Croton.
White fly [46]	Ageratum.

Scale insects.—It is not an uncommon occurrence for ferns to be seriously injured by scale insects, which are often difficult to locate on account of their minute size. At least five species of importance

FIG. 44.—Soft brown scale.

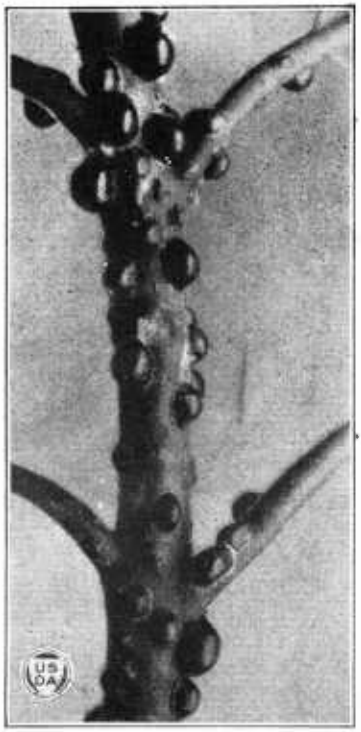

FIG. 45.—Hemispherical scale.

occur on ferns in greenhouses, viz, soft brown scale [47] (fig. 44), hemispherical scale [48] (fig. 45), aspidistra scale,[49] the common mealybug,[50] and the long-tailed mealybug.[51] The soft brown scale has a world-wide distribution and infests many species of plants. The adult female, which varies somewhat in color from bright yellow to a yellowish brown and is about one-fifth of an inch long, gives birth to living young. The hemispherical scale has an equally wide dis-

[45] (*Aramigus*) *Pantomorus fulleri* Horn.
[46] *Aleurotulus filicum* Goeldi, *A. nephrolepidis* Quaintance.
[47] *Coccus hesperidum* L.
[48] *Saissetia hemisphaerica* Targ.
[49] *Hemichionaspis aspidistrae* Sign.
[50] *Pseudococcus citri* Risso.
[51] *P. adonidum* L.

tribution and infests a wider range of food plants. As its name implies, it is hemispherical in shape, and by the use of a hand lens the adult may be readily distinguished from the soft brown scale by its smooth surface, brown color, and the minute white dots to be seen on the skin. It differs also from the soft brown scale in that the young hatch from eggs which are deposited under the scale.

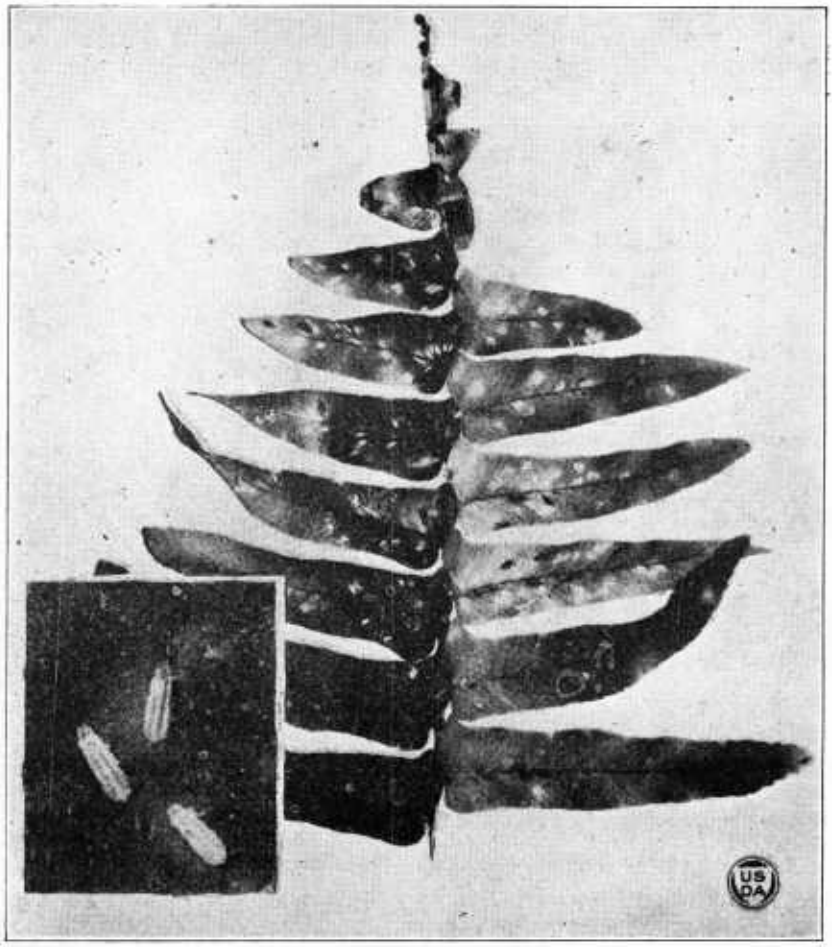

FIG. 46.—Fern frond infested with fern scale. Insert, female and males. Enlarged.

The aspidistra scale is much smaller than those previously referred to, and is a pest of considerable importance to ferns in this country as well as in Europe, Asia, and Australia. The adult female (fig. 46) is about two twenty-fifths of an inch long, resembling somewhat an oyster shell in shape, and is pale yellowish or brown. The male scale is snow-white, ridged, and, although smaller, is more conspicuous.

Control.—The first three of the above-named scale insects may be controlled by fumigating the plants three or four times at weekly

intervals with hydrocyanic-acid gas, using not less than 1 ounce of sodium cyanide per 1,000 cubic feet of space with an exposure of one hour.

For the common mealybug and the long-tailed mealybug, see "Coleus."

The fickle midge,[52] a tiny black "fungus gnat" (fig. 47), often injures the roots of ferns, carnation, begonia, coleus, tulip bulbs, and other plants.

The injury is caused by the larvæ working in the soil. They attack the rootlets and burrow into the main roots and root crown, where they seem to promote decay. In addition to the injury to the roots by the larvæ, the adults may become a nuisance when present in large numbers.

The larvæ are tiny white footless maggots less than one-fourth of an inch long, with black heads. They breed very fast, especially

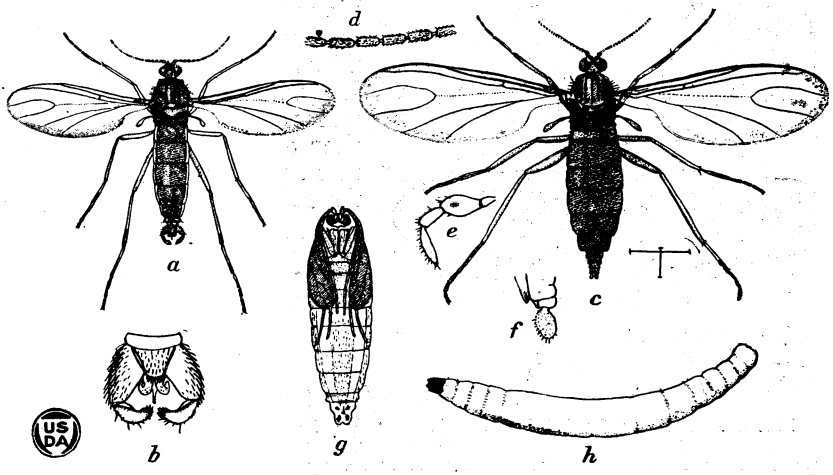

FIG. 47.—Fickle midge: *a*, Male fly from above; *b*, external genital organs of the same; *c*, female; *d*, enlarged antennal joints of same; *e*, maxillary palpus of same; *f*, tip of abdomen of female from side; *g*, pupa, ventral view; *h*, larva, dorsal view. *a*, *c*, *g*, *h*, Much enlarged; *b*, *d*, *e*, *f*, more enlarged. (Chittenden.)

in fresh manure. The full-grown fungus gnats or flies are very delicate, with slender bodies, long legs, small heads, and rounded eyes. They are about one-eighth of an inch long and have a wing expanse of about one-fourth of an inch. The color of the body and legs is pale brownish yellow, with darker brown waist and black head.

Life history.[53]—The whitish eggs are laid by the gnats in the soil or in fresh manure or other organic matter near the base of the plants, and the maggots hatch in about 6 days. Growth and development take about 12 to 14 days, after which the maggots enter the transformation or pupa stage. Before pupating, they spin cocoons which consist of a few silken threads binding together loose bits of earth and fibers. The pupa is about one-sixth of an inch long,

[52] *Sciara inconstans* Fab.

[53] General account of a related new species.

pale yellow, with darker wing pads and still darker head. The antennæ and legs are folded down between the wing pads. Within 5 to 6 days this transformation stage is completed, and just prior to the adult's emergence the pupa works its way to the surface of the soil to allow the escape of the gnat or adult. In confinement, adults may live about one week, and during this period many eggs are deposited. The life cycle from deposition of the egg to emergence of the adult requires from 24 to 32 days.

Control.—Drench the soil in which the plants are growing with mercuric chlorid solution for the destruction of the larvæ and pupæ, or treat the soil with carbon disulphid, or apply tobacco dust liberally to the soil. Since the fickle midge breeds in fresh manure, it is advisable to use only well-rotted manure.

For the control of the adults, light fumigation with hydrocyanic-acid gas at the rate of one-eighth to one-fourth of an ounce of sodium cyanide per 1,000 cubic feet of space should be effective, or tobacco smudges may be substituted. Then follow with either of the above soil treatments to prevent further emergence of the adults from the pupæ remaining in the soil.

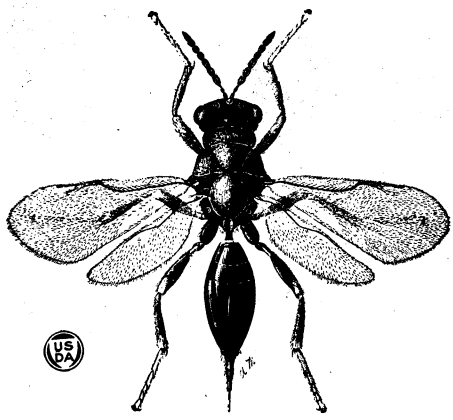

FIG. 48.—Cattleya fly (adult female).

See—
Aphids.....Rose.
Soil insects.....Soil insects.

ORCHIDS.

Cattleya fly.[54]—Orchids of the genus Cattleya, especially *C. gigas*, *C. percivaliana*, *C. triana*, and *C. labiata*, are subject to the attack of the Cattleya fly, which was presumably introduced into the greenhouses of the United States from New Granada about 33 years ago. The injury is occasioned by the larvæ, which burrow out the interior of the young buds or young pseudobulbs, causing them to become weakened and swollen, ultimately turning reddish brown or black, with the result that the embryo flower bud is destroyed.

The adult (fig. 48) is a small, clear-winged, black-bodied, wasp-like insect, the female being about one-seventh of an inch long and the male slightly shorter. The female has a long ovipositor with which the eggs are deposited singly in the small flower bulbs near the base. A single flower bulb may contain from one to eight white, crescent-shaped, footless larvæ, which, when full grown, average about one-sixth of an inch in length (fig. 49). It has been estimated that the life cycle from deposition to emergence may be completed in from 50 to 60 days.

[54] (*Isosoma*) *Eurytoma orchidearum* Westw.

Control.—Examine all growths less than 18 months old at least once a week. All infested parts should be cut out and burned. According to literature, this appears to be the most popular practice among florists.

Injecting insecticides, such as 40 per cent nicotine sulphate solution, into the cavities containing the larvæ and pupæ has also been recommended.

Piercing the buds by means of triangular dissecting pins has been suggested as partially effective for the destruction of the larvæ and pupæ.

Repeated fumigation with hydrocyanic-acid gas, using one-half of an ounce of sodium cyanide per 1,000 cubic feet of space for one hour for an extended period during the winter and early spring, should operate against the adult flies as they emerge.

Trapping the adults by means of a sticky bait, such as ordinary corn sirup or a sweetened sodium-arsenite sirup spread out on paper pie plates and suspended among the plants, has recently been suggested by commercial orchid growers.

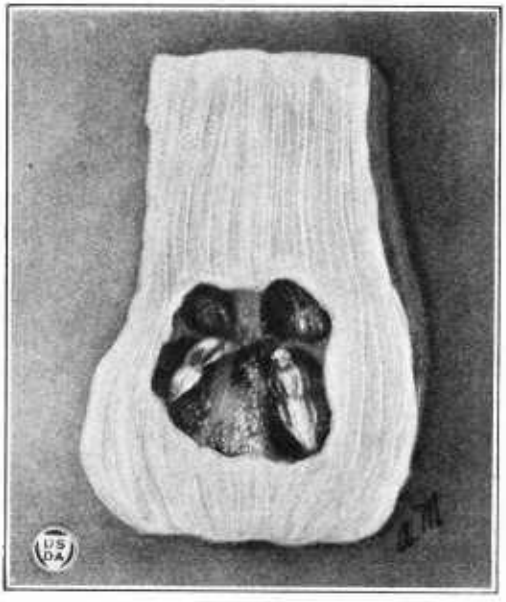

FIG. 49.—Orchid pseudobulb infested with larvæ and pupæ of the cattleya fly. Enlarged.

Orchid bulb-borer.[55]—As its common name indicates, the larvæ of the orchid bulb-borer feed in the interior of and destroy the bulbs of such orchids as Odontoglossum, Lycaste, and various other genera which possess large soft bulbs. Not only does the insect injure the interior of the bulb, but it paves the way for subsequent decay. The adult or weevil (fig. 50) is fairly large and has a light band running lengthwise of its back. The injury by this insect, however, is not confined to the bulbs, since the adults feed on the leaves and other portions of the plant. Usually the infested bulbs can be detected by running the bulbs through the thumb and forefinger, in this manner causing the weakened tissue to give way.

FIG. 50.—The orchid bulb borer. (Weiss.)

Control.—Remove and destroy infested bulbs.

[55] *Eucactophagus weissi* Champ.

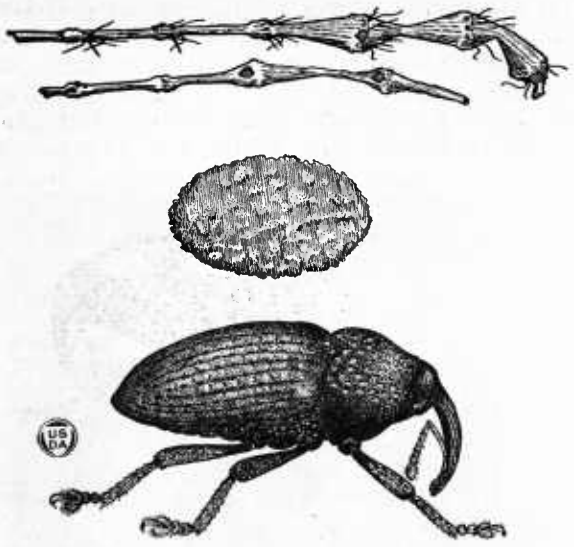

FIG. 51.—Dendrobium weevil: Upper, orchid pseudobulbs showing exit holes of weevils; middle, pupal cell found in the large end of a pseudobulb; lower, the adult weevil. (Weiss.)

Dendrobium weevil.[56]—The Dendrobium weevil (fig. 51), which is approximately one-seventh of an inch long, dull black, and possesses a rather robust snout and legs, is frequently collected in orchid houses. It apparently confines its attack to the orchids belonging to the genus Dendrobium, particularly *D. findlayanum* and *D. crystallinum*. The adults during the middle of the day are usually found in the basal portions of the leaf, where feeding takes place.

Control.—Fumigate plants with hydrocyanic-acid gas, 1 ounce of sodium cyanide per 1,000 cubic feet of space. Spray with arsenate of lead, or dust with the dry mixture of sulphur and arsenate of lead.

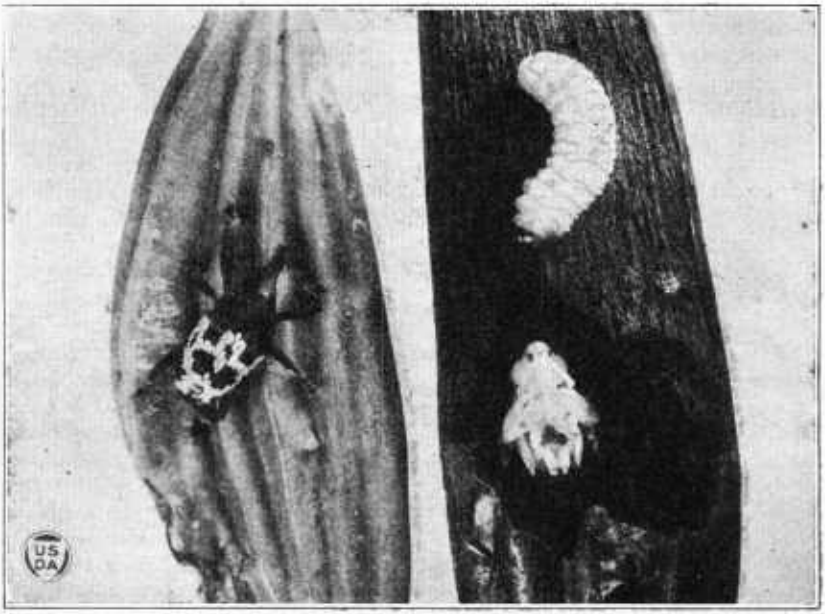

FIG. 52.—Cattleya weevil on orchid: Left, weevil on pseudobulb; right, pupa in its cell on leaf stem, also full-grown larva. Enlarged twice. (Sanders and Fracker.)

[56] *Acythopeus* (*Baridius*) *orchivora* Blackb.

Cattleya weevil.[57]—The cattleya weevil (fig. 52), which is a native of Colombia, is now known to be established in greenhouses in New Jersey and Wisconsin. It is apparently being distributed from house to house with infested plants, and at times is responsible for serious injury. The adult is approximately seven-sixteenths of an inch long and characteristic white marks are to be found on its back. Plants are injured by both the adult and the larva, the former feeding on the surface of the pseudobulbs and puncturing the leaves and the latter feeding on and developing within the leaf, stem, or pseudobulb of the infested plant, subsequently causing the stem to decay and fail to bear flowers.

Control.—Control is the same as for the Dendrobium weevil.

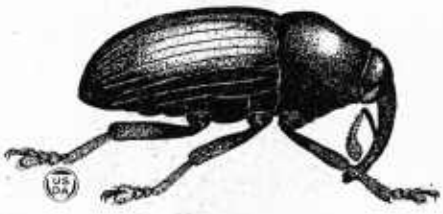

FIG. 53.—The black Diorymerellus. (Weiss.)

Black Diorymerellus.[58]—The black Diorymerellus (fig. 53) is a shiny black beetle slightly less than one-twelfth of an inch long. It has at times been found very abundant in orchid houses, feeding on Cattleya and Dendrobium. The adults not only feed on the leaves, flower stalks, and pseudobulbs, but they are credited with occasioning considerable damage to flowers and unopened flower buds. Occasionally the adults can be seen crawling sluggishly over the plants, but usually they are found concealed in the basal part of the leaf or in the sheath surrounding the flower stalk.

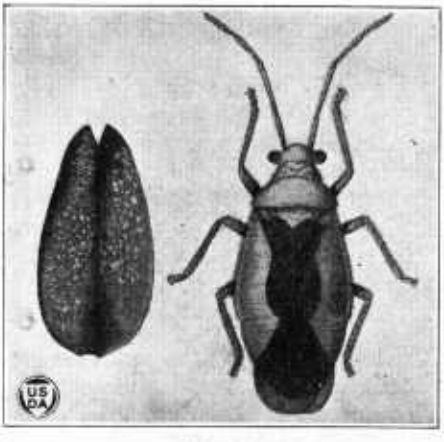

FIG. 54.—Orchid plant-bug: Left, orchid leaf showing injury; right, adult. (Weiss.)

Control.—Use arsenical sprays and dusts as recommended for the Dendrobium weevil and fumigate plants with hydrocyanic-acid gas in a box at the 1-ounce sodium cyanide rate.

Florists have reported some relief by sending a man through the house daily to search out and destroy all these weevils that could be found on the plants.

The orchid plant-bug[59] (fig. 54), a beautiful red and blue plant-bug about one-sixth of an inch long, which has been intercepted on numerous occasions on cattleyas imported from Colombia, Brazil, Mexico, and Venezuela, has been found to be established in a few of the orchid houses of this country. Infested plants show characteristic irregular white spots on the under surface of the leaves, due to the extraction of the chlorophyll by the adults and nymphs as they feed.

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[57] *Cholus cattleyae* Champ. [58] *Diorymerellus laevimargo* Champ.
[59] *Tenthecoris bicolor* Scott.

Control.—Spray plants with contact insecticides, such as nicotine sulphate, nicotine oleate, or soap solution, taking care to hit the undersides of the leaves.

Fumigate with hydrocyanic-acid gas, using one-half ounce of sodium cyanide per 1,000 cubic feet.

See also control of plant-bugs under "Sweet pea."

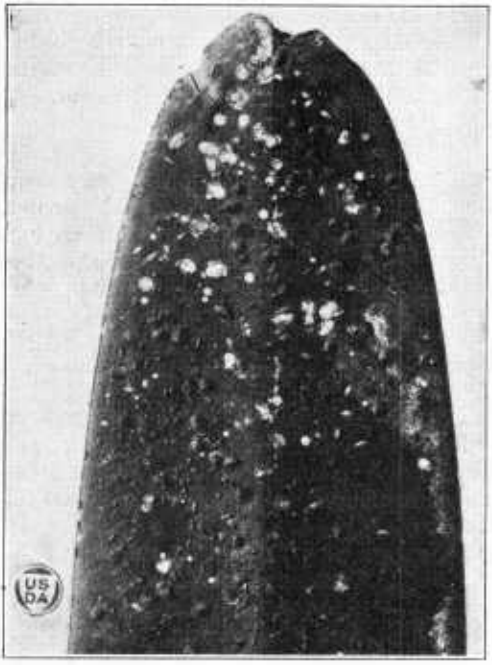

FIG. 55.—Portion of orchid leaf showing orchid scale.

Cattleya midge.[60]—The irritation caused by the feeding of the yellowish maggots of the Cattleya midge on the young roots of cattleyas and other species of orchids causes the plant to develop unsightly galls in which the maggot lives. While not considered at the present time an injurious insect, if it is present in sufficient numbers the vitality of the plant is greatly reduced.

Control.—Remove and destroy enlarged galls or rootlets in which the larva lives.

Orchid scale.[61]—Orchids are occasionally injured by the attacks of the orchid scale. The female scale (fig. 55) is brown and somewhat larger than the Florida red scale. The male scale differs from the female in that it is smaller and not circular in outline.

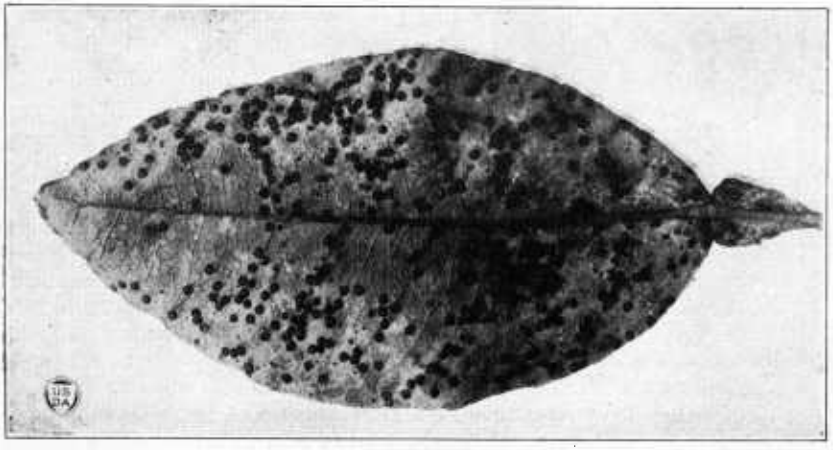

FIG. 56.—Leaf infested with Florida red scale.

[60] *Parallelodiplosis cattleyae* Moll. [61] *Chrysomphalus biformis* Ckll.

Boisduval's scale.[62]—The female of Boisduval's scale is circular, from one twenty-fifth to two twenty-fifths of an inch in diameter, and varies from snow-white to light yellow in appearance. The male scale is white, about one twenty-fifth of an inch long, and possesses three distinct ridges on the back.

This scale insect has a wide distribution and has been recorded as infesting the following plants: Phoenix, Kentia, Washingtonia, and orchid.

Proteus scale.[63]—It is not uncommon to find orchids and palms infested with the proteus scale. The female scale is more or less oval, two twenty-fifths of an inch in diameter, and greenish brown, whereas the male scale is elongate, about one twenty-fifth of an inch long, and light gray. The chaff scale,[64] a closely related species, has also been taken on citrus and other plants grown in greenhouses.

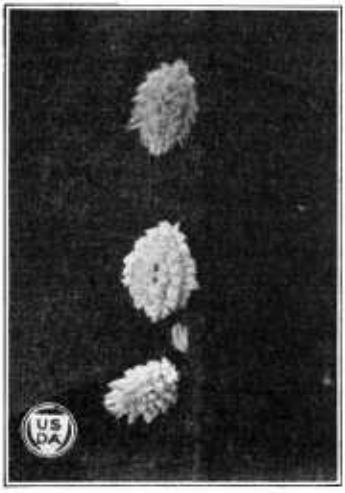

Fig. 57.—Palm mealybug. Enlarged.

Other scale insects which may infest orchids and miscellaneous plants grown in greenhouses are the following: Box scale,[65] camellia scale,[66] latania scale,[67] cyanophyllum scale,[68] black scale,[69] pineapple scale,[70] Morgan's scale,[71] greedy scale,[72] red or orange scale,[73] zamia scale,[74] and Florida red scale.[75]

Control.—See control for "Palms."

Orchid thrips.[76]—A very minute, active insect, yellowish in color, has been found attacking orchids in California, Washington, D. C., and Louisville, Ky. It is especially destructive on cypripediums and to a less extent on cattleyas. During the younger or nymphal stages these thrips conceal themselves between the sheaths and there the eggs are probably deposited. The full-grown insects move about very actively and on the least disturbance will disappear into space by springing away.

Control.—Persistent fumigation with hydrocyanic-acid gas, using one-half an ounce of sodium cyanide per 1,000 cubic feet of space, for one hour, is recommended as a control measure.

	See—
Palm aphis[77]	Palms.
Black vine-weevil[78]	Ferns.
Cyclamen mite	Cyclamen.
Sowbugs, Millipeds, Ants	Soil insects.

[62] *Diaspis boisduvalii* Sign.
[63] *Parlatoria proteus* Curt.
[64] *Parlatoria pergandei* Comst.
[65] *Pinnaspis buxi* Bouché.
[66] *Fiorinia fiorinae* Targ.
[67] *Aspidiotus lataniae* Sign.
[68] *Aspidiotus cyanophylli* Sign.
[69] *Saissetia oleae* Bern.
[70] *Diaspis bromeliae* Kern.
[71] *Chrysomphalus dictyospermi* Morg.
[72] *Aspidiotus rapax* Comst.
[73] *Chrysomphalus aurantii* Mask.
[74] *Aulacaspis zamiae* Morg.
[75] *Chrysomphalus aonidum* L.
[76] *Euthrips orchidii* Moult.
[77] *Cerataphis lataniae* Boisd.
[78] (*Otiorhynchus*) *Brachyrhinus sulcatus* Fab.

FIG. 58.—Tessellated scale on the lower surface of a leaf. (Moznette.)

PALMS.

Florida red scale.[79]—Of the many species of scale insects which attack palms, the Florida red scale (fig. 56), which has a wide range of food plants and is of world-wide distribution, is perhaps the most troublesome. Under glass it has been found to infest the following genera: Areca, Latania, Cycas, Howea, Kentia, Phoenix, and others. This little insect is peculiarly adapted to a moist climate and therefore thrives under greenhouse conditions. The female scale is circular, about two twenty-fifths of an inch in diameter, rich reddish brown at times almost black, with a lighter central portion, giving the appearance of a dark ring with a light center. Breeding continues throughout the year, and it is safe to assume that there are between five and seven generations annually, depending on both the temperature and the humidity.

Palm mealybug.[80]—It is not an uncommon occurrence to find palms infested with the palm mealybug (fig. 57), which is oval and heavily coated with a white powdery secretion. The margin of its body is fringed with 24 waxy appendages, and it may be distinguished from the common mealybug and the long-tailed mealybug by the rows of pyramidal waxy secretions on its back.

Tessellated scale.[81]—Like most of the scale insects inhabiting greenhouses, the tessellated scale (fig. 58) infests a long list of plants, and when present in sufficient numbers is capable of seriously injuring palms. The injury is not confined to its feeding, which is a drain on the vitality of the plant, but it secretes a sweet fluid known as honeydew which serves as a medium for the development of sooty

[79] *Chrysomphalus aonidum* L.
[80] *Pseudococcus nipae* Mask.
[81] *Eucalymnatus tessellatus* Sign.

mold, which affects the normal respiration of the plant. The scale is exceedingly flat, more or less oval, about one-sixth of an inch long and one-eighth of an inch wide, brown to dark brown, and the surface of the body is broken up into plates or tessellations which are usually discernible with the naked eye.

Thread scale.[82]—This tenacious little pest, the thread scale (fig. 59), is found on both surfaces of the leaves and is at times a very serious enemy of palms. Because of its small size and its habit of attaching itself parallel to the ribs of the leaf, it is frequently unobserved by the grower until the plants become severely infested. The adult female scale, as its common name suggests, is very narrow, in general color dark brown to black, and about one-sixteenth of an inch long.

FIG. 59.—Thread scale. Enlarged.

Ivy or oleander scale.[83]—It is not uncommon to find palms heavily incrusted with the ivy or oleander scale (fig. 60), which is known to attack a great variety of tropical and subtropical plants, and those grown under glass. The male scales are pure white and frequently greatly exceed the females in abundance. The female scales are light buff, occasionally showing a faint purplish tinge, and are from two to three times as large as the male scales.

Palm aphis.[84]—Superficially the palm aphis (fig. 61) resembles a scale insect, or possibly the pupa of the white fly. After securing a good feeding place it remains attached at that point throughout life. The insect is brown to black, very flat, oval, and has a fringe of white waxy filaments around the entire edge. It is usually found on the upper surfaces of infested leaves, and has been reported to occur in California, Indiana, Washington, D. C., and a few other localities.

Control.—Nearly all the scale insects which attack palms may be successfully controlled by persistent and systematic fumigation of the greenhouse, using not less than 1 ounce of sodium cyanide per

[82] *Ischnaspis longirostris* Sign. [83] *Aspidiotus hederae* Vall. [84] *Cerataphis lataniae* Boisd.

1,000 cubic feet of space. Whenever practicable the plants should be fumigated in a box at the rate of 2½ ounces to 1,000 cubic feet of space. The treatment should be repeated two or three times at intervals of 3 or 4 weeks.

If it is impracticable to fumigate, spray or dip the plants in kerosene nicotine oleate, 1 to 20, kerosene emulsion, 5 per cent, or soap solution, 1 to 4.

	See—
Fuller's rose beetle	Rose.
Weevils	Ferns.
Thrips	Croton.

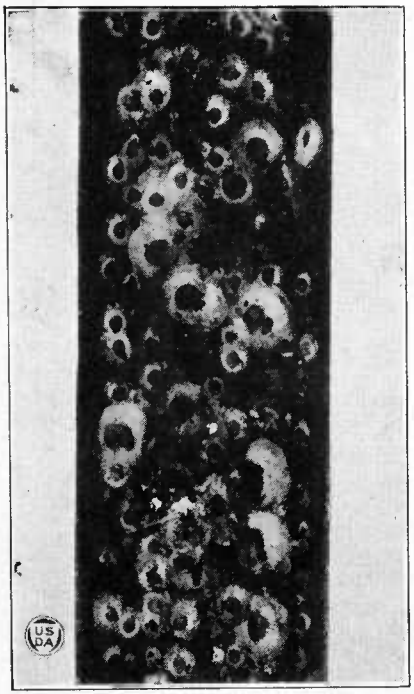

FIG. 60.—Ivy or oleander scale. Enlarged.

FIG. 61.—Orchid leaf infested with palm aphis.

PANSY.

See insects discussed under "Violets."

PRIMULA.

	See—
White fly	Ageratum.
Leaf-tyer	Cineraria.
Aphids	Rose.
Thrips	Crotons. Carnation.

ROSE.

Rose midge.[85]—The rose midge (fig. 62) is one of the most serious insect enemies with which the rose grower has to contend. It has

[85] *Dasyneura rhodophaga* Coq.

been recorded as infesting Sunburst, Ophelia, Mme. Butterfly, Columbia, Radiance, Hadley, Mrs. Charles Russell, Killarney, Mrs. Aaron Ward, Hoosier Beauty, Mrs. George Shawyer, American Beauty, and many other varieties. It has also been found to infest outdoor roses in Canada. The losses sustained in certain sections as a result of the attack of the maggot amount to large sums annually.

The adult is a fragile, two-winged insect about one-sixteenth of an inch long, of a yellowish color, with the head and forepart of the body tinged with brown. The adult female has a long ovipositor,

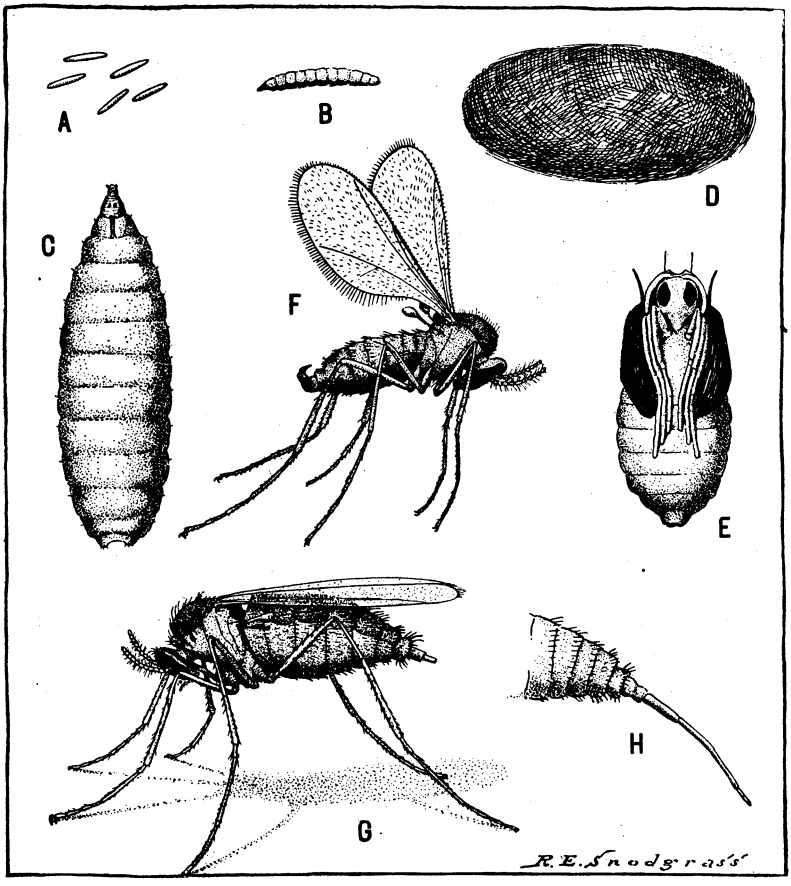

FIG. 62.—The rose midge, enlarged about 27 diameters: *A*, Eggs; *B*, young larva; *C*, full-grown larva; *D*, cocoon; *E*, pupa; *F*, adult male; *G*, adult female; *H*, female ovipositor. (9th Ann. Rept. State Ent. Ind.)

which is used in laying the small yellowish eggs, barely visible to the naked eye, on succulent growth under the sepals of the flower buds, on the axils of tender leaves, or between the unfolded leaves of the leaf buds. Under favorable temperature conditions the eggs hatch in two days, and the young maggots or larvæ immediately begin to feed at the base of the flower buds or on the upper side of the tender leaves and leaf petioles, causing them to become distorted, turn

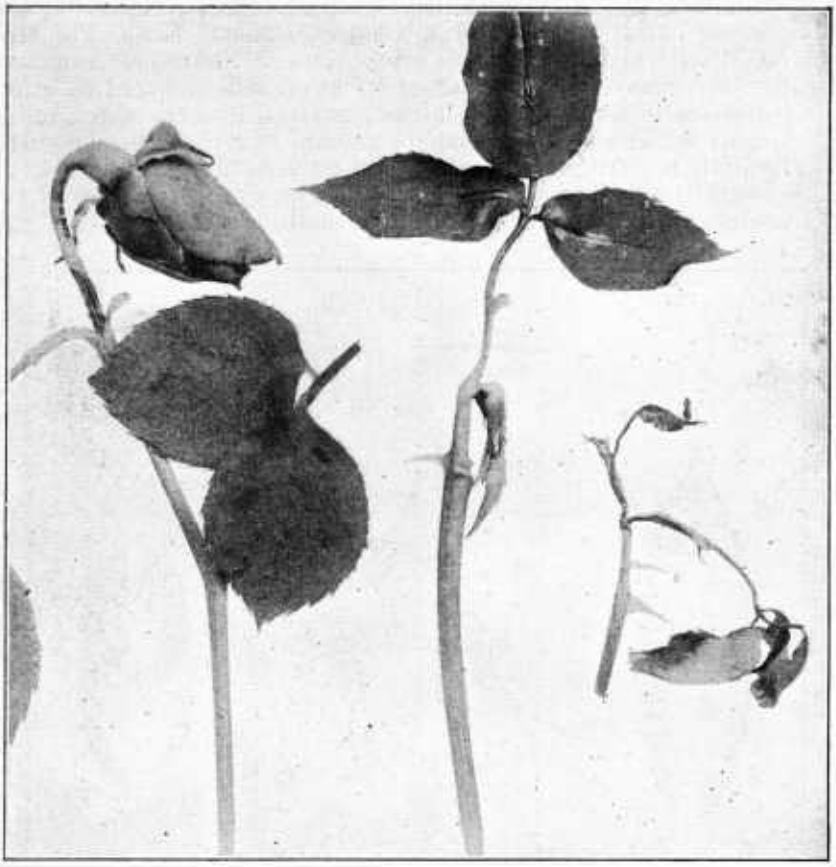

FIG. 63.—Young leaves and flower buds of roses injured by larvæ of the rose midge. (Sasscer and Borden.)

FIG. 64.—Rose midge larvæ. Enlarged.

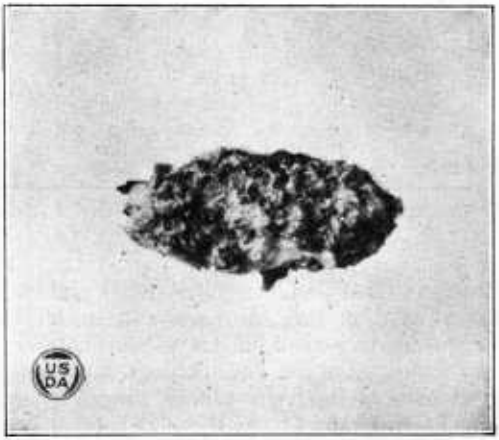

FIG. 65.—Rose midge cocoon. Enlarged.

brown, and ultimately die (fig. 63). An infested bud, upon close examination, will frequently reveal from 20 to 30 tiny white maggots (fig. 64). These reach maturity in about a week and are then of an orange color, legless, and one-twelfth of an inch long. They then work their way out of the bud and fall to the ground, which they enter. After constructing a small white cocoon (fig. 65) they pupate. In from 5 to 7 days they appear as adults, and subsequently egg laying takes place. Under greenhouse conditions the life cycle requires from 12 to 16 days. The principal injury is done during the period from the latter part of May to the latter part of July and from September until early November. Overwintering cocoons are constructed in late fall, and under normal conditions the adult is seldom seen in injurious numbers until May or June. No injury has been reported during the winter months, although larvæ have been observed infesting buds as early as February 22.

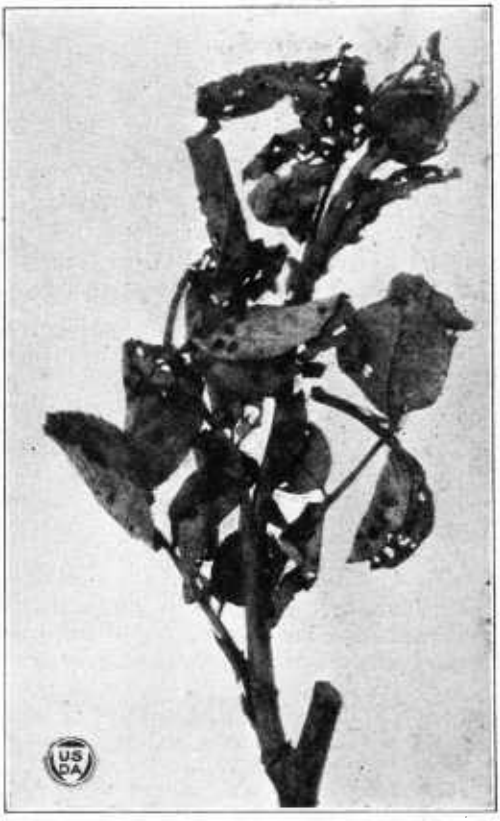

FIG. 66.—Terminal growth of rose injured by beetles of strawberry rootworm.

Control.—To control the rose midge it is necessary to fumigate nightly with nicotine or tobacco fumes and also to keep the soil covered with a layer of tobacco dust about one-fourth inch deep. The nightly fumigation destroys the flies, which live only one day, and also destroys the larvæ on the plants. The tobacco dust cover kills the larvæ or pupæ on or in the soil. In case of severe infestation, remove the topsoil early in the spring and replace with fresh soil.

Where earth walks are present it is advisable to spray them, as well as the soil beneath the benches, with the kerosene nicotine oleate, or kerosene emulsion, 5 per cent.

Strawberry rootworm or leaf-beetle.[86]—Until within the last three years the strawberry rootworm or leaf-beetle, a native insect, was

[86] *Paria canella* var. *quadrinotata* Say and *gilvipes* Crotch.

considered a serious enemy of strawberries, raspberries, and other plants. Suddenly, almost suggesting preconcerted action, this little beetle appeared in greenhouses, attacking roses in Virginia, Indiana, New Jersey, Pennsylvania, and Maryland. Losses due to injury to

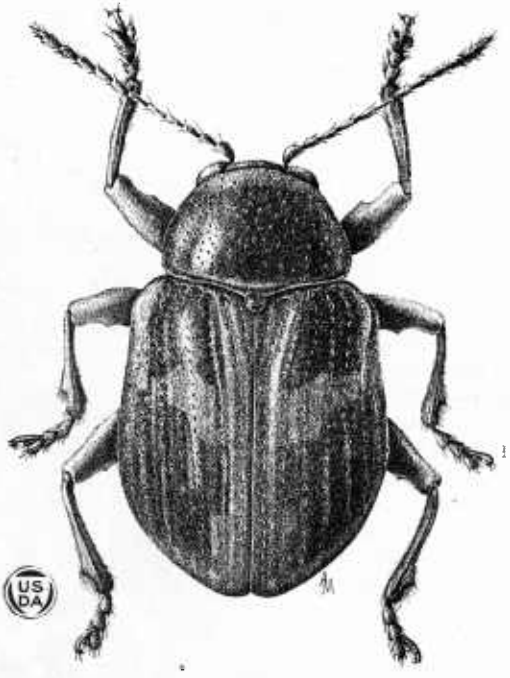

FIG. 67.—Adult or beetle of the strawberry rootworm.

greenhouse-grown roses caused by this insect in two counties in Pennsylvania have been estimated at approximately $70,000 in one season. Injury is occasioned by the larvæ or grubs and also by the beetles.

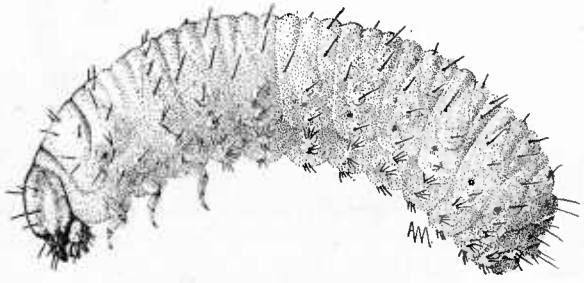

FIG. 68.—Mature larva of the strawberry rootworm or leaf-beetle.

The former feed on the young rootlets and also weaken the plant by girdling the more mature roots. The beetles show a decided preference for the new eyes and young shoots, especially after the resting period at the critical time when the plants are developing new growth, thereby ruining the future crops. They also feed vora-

ciously on the foliage, chewing small, more or less round holes in the leaves (fig. 66), which gives them the appearance of having been fired into at close range. Ultimately the infested plants become stunted as the result of the injury done to the roots and foliage.

The adults or beetles (fig. 67) are about one-eighth of an inch long, oval, highly polished, and vary in color from black to yellowish brown, with usually four spots on the wing covers, which in addition have longitudinal rows of minute pits. Under confinement the beetles have lived from 150 to 364 days, and as many as 216 eggs have been deposited by one female. The beetles may be easily collected in dead or curled-up leaves and dried rubbish, but upon the slightest disturbance they play "possum" and feign death. The eggs, which are first white but later turn yellow, are usually deposited in masses of from 4 to 15 in dried-up or dead leaves. The eggs hatch in from 7 to 15 days, and the larvæ immediately enter the soil and begin to feed on the rootlets, reaching maturity (fig. 68) in from 35 to 60 days. The pupa (fig. 69) requires from 8 to 13 days to develop, after which the beetle appears. Beetles which appear in the fall remain over winter in the mulch or soil and occasionally feed on clear sunny days. Egg laying begins in the latter part of February and continues throughout March and early April. There are at least two generations annually, and all forms may be found at any time of the year, although the beetles are most numerous in June and July and September and October. Very few eggs are deposited after August.

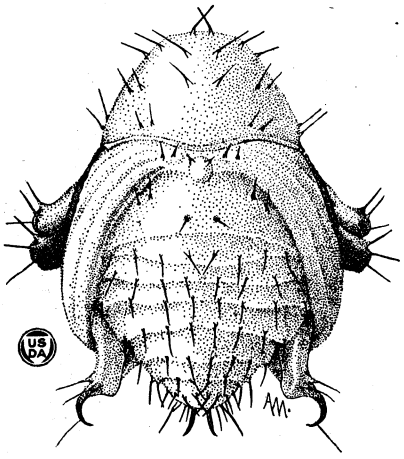

FIG. 69.—Pupa of the strawberry root-worm or leaf-beetle.

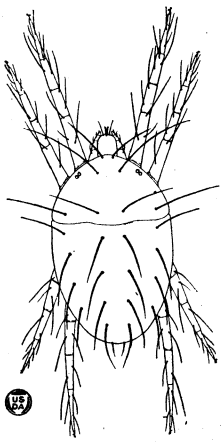

FIG. 70.—Common red spider adult. (Banks.)

Control.—Collect and burn all dead and dry leaves at least once every 10 days during the egg-laying period from February to September. Replant in a systematic manner so that no plants remain in the houses over three seasons. This is a drastic but effective way of combating the insect. Apply tobacco dust to the soil regularly, as ordinarily used for fertilizer, or alternate with wood ashes. As the potash or alkali contained therein leaches down through the soil, it should operate against the larvæ and pupæ.

During the resting or drying period of the plants, fumigate three or four times at intervals of three days, after dark, with hydrocyanic-acid gas, using from 1½ to 2 ounces of sodium cyanide per 1,000 cubic feet of space, with an exposure of two hours. This will

kill most of the adults which are above the soil. Follow immediately by spraying the cut-back plants with arsenate of lead, to prevent girdling by the few adults which were not killed and those which emerged from the soil subsequent to the fumigation; and when the new growth starts, keep it well and constantly covered with a dry mixture of 1 part arsenate of lead or calcium arsenate and 9 parts superfine sulphur.

Red spider.[87]—The common red spider, which is not a true insect but a mite, is generally distributed throughout the United States and attacks a long list of ornamental plants, especially roses, violets, and carnations grown under glass. When full grown (fig. 70), it is about one-fiftieth of an inch long, of a general reddish color frequently tinged with yellow, green, and orange. Owing to their minute size and their habit of spinning and concealing themselves under small webs, they frequently remain unnoticed until they are present in sufficient numbers to cause serious injury to the infested plants. The injury to roses is almost wholly confined to the under surface of the leaves, which lose their color and eventually fall (fig. 71). Heavily infested plants are further disfigured by the white webs constructed by these little pests, especially if the plant can not be regularly syringed with water. In other words, they thrive on plants grown in sandy soil, high temperature, and a dry atmosphere. They reproduce very rapidly, requiring only seven or eight days to develop from egg to adult, making the total life cycle, including the life of the adult, about three or four weeks.

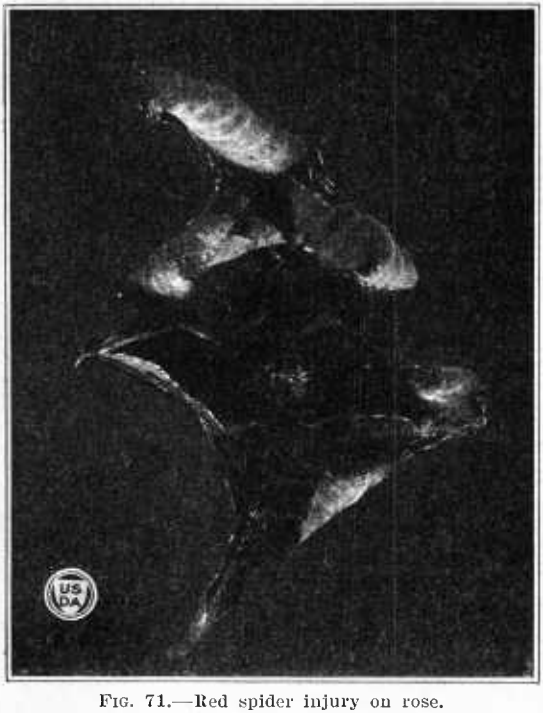

FIG. 71.—Red spider injury on rose.

Control.—Mites have a peculiar structure of the respiratory system which renders them very resistant to fumigation with either tobacco or hydrocyanic-acid gas. As a control measure, therefore, fumigation is precluded.

On roses frequent syringing with clear water under pressure of at least 25 pounds is a very effective and practical means of keeping this pest in check. This operation dislodges the mites, causing them to fall to the ground, where they become lost in the mud. It also

[87] *Tetranychus telarius* L.

disturbs the webbing used by these creatures for egg deposition, travel, and protection. In commercial houses the frequency of syringing is necessarily dependent on the weather conditions; it can not be done during cloudy spells, and, moreover, with varieties which are susceptible to mildew and black spot, the greatest care must be exercised. By using nozzles especially adapted for syringing, the surplus water can be directed so that it will run off into the walks and the heavy drenching of the beds is avoided. The frequent watering keeps the atmosphere moist, which is detrimental to the development of the mites.

FIG. 72.—Portion of rose house showing severe injury by oblique-banded leaf-roller. Inset, injured rosebuds. (Sanderson and Jackson.)

If syringing is not feasible and spraying must be resorted to, use the tobacco extracts, nicotine solutions, soap solutions, nicotine oleate, flour paste, or sulphur mixed with water, applications being made at weekly intervals until the infestation subsides.

Frequent application of superfine sulphur is also very effective in holding the mites in check. This material is best applied with the modern hand dust guns, several types of which can be purchased.

The rose or oblique-banded leaf-roller.[88]—As its common name implies, the caterpillars of the rose leaf-roller conceal themselves by rolling or folding a leaf or by tying several leaves together with fine silken threads. In the case of a light infestation the caterpillars are usually found on the older lower leaves, but if present in numbers

[88] *Cacoecia rosaceana* Harr.

they tie the terminal leaves together, checking the normal growth of the plant (fig. 72). The most serious damage is caused by the eating of the flower buds. In addition to the rose it feeds sporadically on other members of the rose family, as well as carnation and aster.

The moth (fig. 73) has a wing expanse of from seven-eighths of an inch to 1¼ inches, is light brown, with usually three dark brown bands running obliquely across the forewings. The eggs are yellowish green and are laid in compact masses containing an average of 117 eggs, the masses varying in size from one-fourth to one-half inch in length. They are deposited on the older leaves at night or on cloudy days, and a single female may deposit as many as 650 eggs. They hatch in from 6 to 7 days if the temperature in the house averages 80° F., or from 10 to 11 days in a temperature of 70° F. The

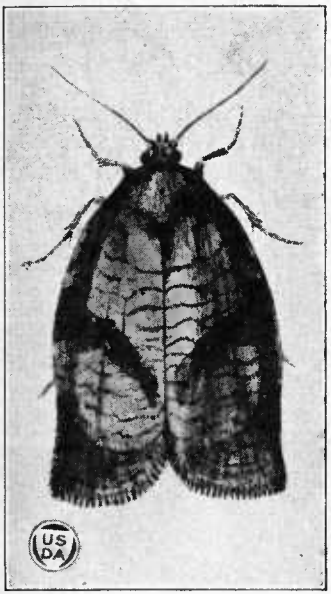

FIG. 73.—Moth of oblique-banded leaf-roller. Enlarged. (Quaintance.)

FIG. 74.—Larvæ of oblique-banded leaf-roller. Enlarged. (Sanderson and Jackson.)

young caterpillars (fig. 74) are active and if disturbed will drop from the leaf, suspending themselves by delicate threads. It requires about 33 days for the caterpillars to become full grown, and when they reach that stage the leaves are drawn together firmly and a cocoon formed. Normally the adult appears in from 6 to 7 days after pupation. The full life cycle may be completed in about 7 weeks if the temperature averages 80° F., and if the temperature is lower the length of the life cycle is correspondingly increased.

Control.—Dust with arsenate of lead and superfine sulphur, 1 to 9; spray with arsenate of lead or Paris green.

Use trap lights as recommended for cutworms.

Hand picking is suggested when only a very light infestation exists.

Rose aphids.—Plant-lice or aphids, occasionally referred to as "lice" or "green fly," often become abundant on roses. The principal injury is occasioned by two species, namely, the rose aphis [89] and the small green aphis,[90] both of which may occur on the same plant. Aphids are provided with sucking mouth parts with which the plant tissues are pierced and the vital juices sucked up. On account of their small size they are frequently overlooked until they have increased to sufficient numbers to cause the tender growth to become stunted, the leaves to curl up, and the plants disfigured.

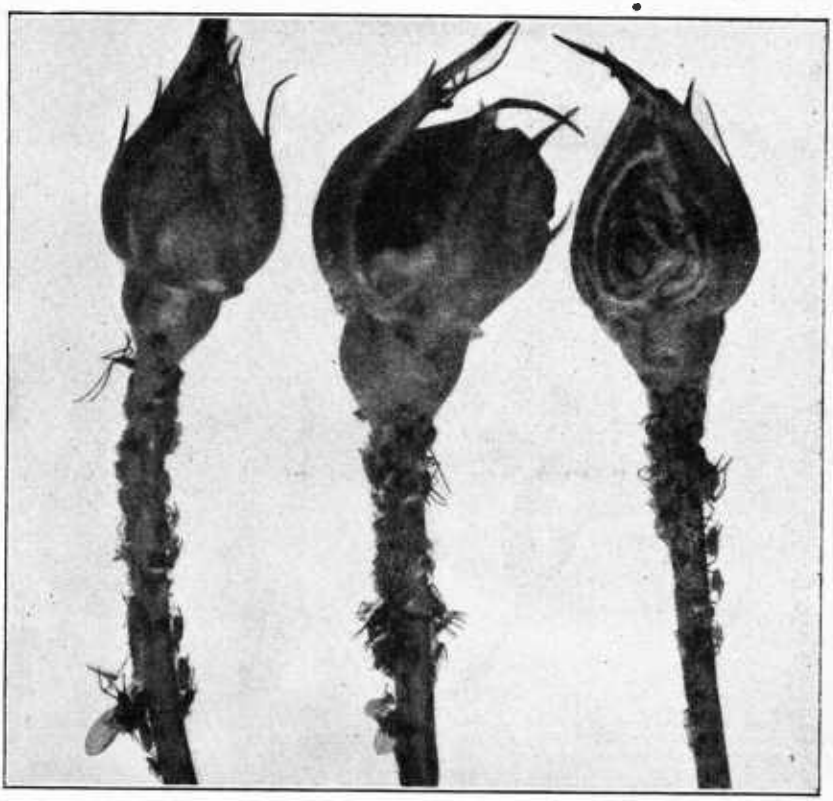

FIG. 75.—Rose buds showing colonies of the rose aphis. Enlarged. (Russell.)

Besides extracting the vital juices of the plants, aphids excrete a sweetish liquid or honeydew which is attractive to ants, and serves as a medium for the development of sooty mold, an objectionable black deposit which reduces the commercial value of the plants and flowers. They are gregarious in their habits, living in colonies, usually on the underside of leaves and young terminal growth. In these colonies may be found wingless and winged females in all stages of development, from small newly born to full-grown individuals (fig. 75).

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[89] *Macrosiphum rosae* L. [90] *Myzus rosarum* Kalt.

Control.—The standard methods of controlling plant-lice in greenhouses are by the use of hydrocyanic-acid gas, at the rate of one-half ounce of sodium cyanide per 1,000 cubic feet of space for one hour (p. 12), vaporization of nicotine extracts (p. 12), and spraying with contact and nicotine insecticides (p. 6).

The fumigation with hydrocyanic-acid gas is practicable, especially during the hot weather, when it is inconvenient to smoke with tobacco extracts, which require the house to be closed for the greater portion of the night, while with the hydrocyanic-acid gas the operation is over in one hour. Even though the temperatures run high,

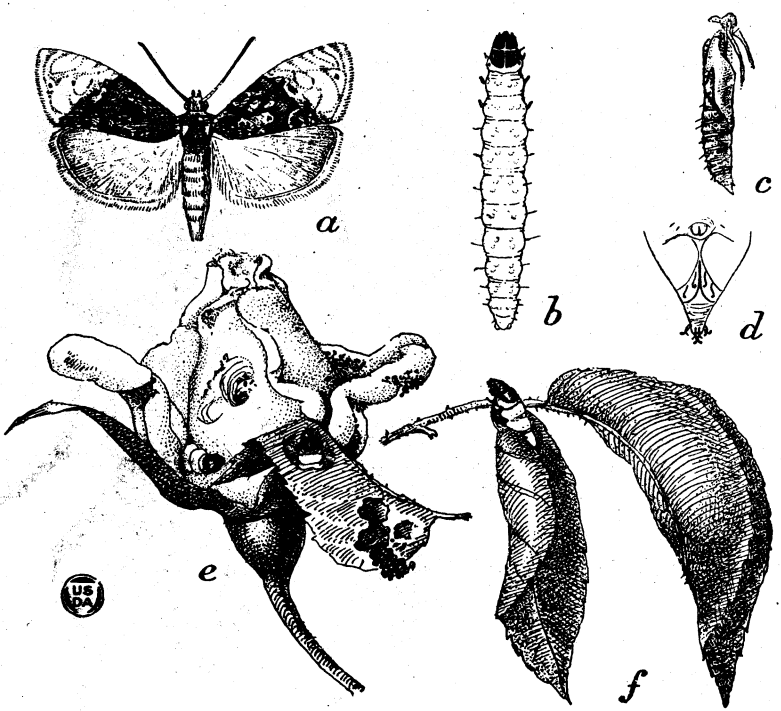

FIG. 76.—Rose budworm: *a*, Moth; *b*, larva; *c*, empty chrysalis skin; *d*, terminal segment of pupa; *e*, rosebud, showing larva at work; *f*, leaves folded by larvæ. All twice natural size, except *d*, which is greatly enlarged. (Chittenden.)

the injury likely to result from hydrocyanic-acid gas would not compare with that from tobacco fumes.

The standard material used for spraying against plant-lice, either in greenhouses or on outdoor plants, is the 40 per cent nicotine sulphate solution.

Dusting the plants early in the morning with dry tobacco dust or nicotine sulphate dust is also satisfactory.

Rose budworm.[91]—Although the rose budworm (fig. 76) as a destructive pest does not rank with the rose midge, it occasionally appears in sufficient numbers during the cut-flower season to cause the grower much apprehension. It occurs sporadically and has a rather wide distribution, being recorded from Massachusetts, New

[91] *Olethreutes nimbatana* Clem.

York, Pennsylvania, Illinois, Wisconsin, Indiana, and the District of Columbia. Unfortunately the complete life history of this insect is not known, but it is assumed that the eggs are laid at night on the terminal growth. The young caterpillars immediately upon hatching draw together the folded leaves or enter the unopened buds, within which they feed, being especially destructive to the latter, as shown in Figure 76. The full-grown caterpillar is approximately five-eighths of an inch long, greenish, with a black head. The parent insect is a small moth with a wing expanse of about five-eighths of an inch, brownish gray in general color. Under greenhouse conditions there are at least two generations annually, probably more.

Control.—Destroy the caterpillars in folded leaves or unopened buds by pinching off and burning. Dust with superfine sulphur and arsenate of lead (p. 9).

Rose leaf-tyer[92] **and greenhouse leaf-roller.**[93]—The leaf-tyers are closely related to and in habits do not differ from the rose budworm, and, therefore, may be controlled by the same measures.

Thrips.—Several species of thrips injure the buds of roses, the principal offender being the so-called onion thrips[94] which frequently appears in abundance on American beauties. (See "Carnation.")

Fuller's rose beetle.[95]—Fuller's rose beetle (fig. 77), a snout-beetle about one-fourth to three-eighths of an inch long, dirty brown or gray, with a whitish diagonal line on each wing cover, is very injurious to roses and geraniums, as well as other greenhouse plants, including carnations, camellias, abutilons, begonias, lilies, gardenias, primroses, cannas, and citrus plants. Injury is occasioned by both the beetles and the larvæ, the former feeding on the foliage buds and flowers and the latter on the roots. The beetles are very active at night and do most of their feeding after dusk, remaining in concealed places during the day. Like many of their close relatives, they feign death and drop to the ground if disturbed. They not only feed on the foliage but sever the leaves from the plants.

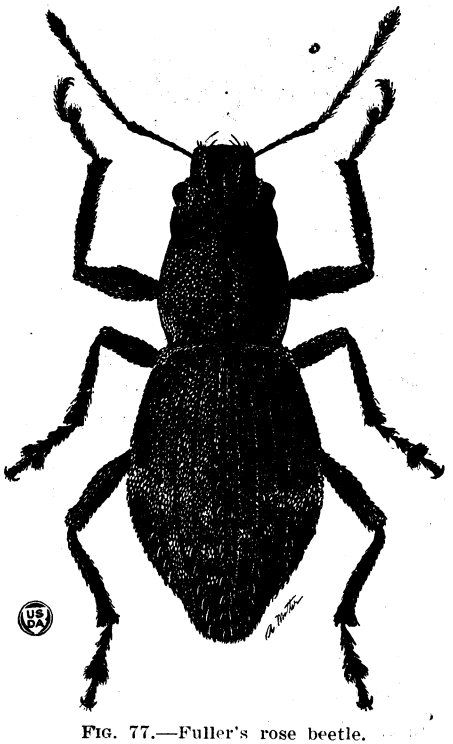

FIG. 77.—Fuller's rose beetle.

The eggs are pale translucent yellow, ellipsoidal, and about one twenty-eighth of an inch long. They are deposited in masses of

[92] *Olethreutes cyanana* Murtf.
[93] *Cacoecia parallela* Rob.
[94] *Thrips tabaci* Lind.
[95] *Pantomorus fulleri* Horn.

about 60 each between the layers of loose bark near the base of the plant. They hatch in about a month. The larvæ then burrow into the ground and feed on the young roots, where they pupate and later emerge as adults. As this insect is primarily a greenhouse pest, all stages may be found during the winter and early spring months, although the adults are more numerous during November and December, when the injury is most noticeable. The grubs and beetles closely resemble those of the black vine weevil. (See "Ferns.")

Control.—Jar the infested plants. This will cause the beetles to fall to the ground, where they can be collected and destroyed.

Carbon disulphid may be applied near the base of plants to destroy grubs at the roots, but injury often follows when this material is used on rose. Tobacco stems or dust applied to the soil should also operate against the larvæ and pupæ.

Spray the plants with arsenicals for the adults.

Pull out and burn the most severely infested plants and replenish with fresh soil.

See also control as given under black vine weevil. (See "Ferns.")

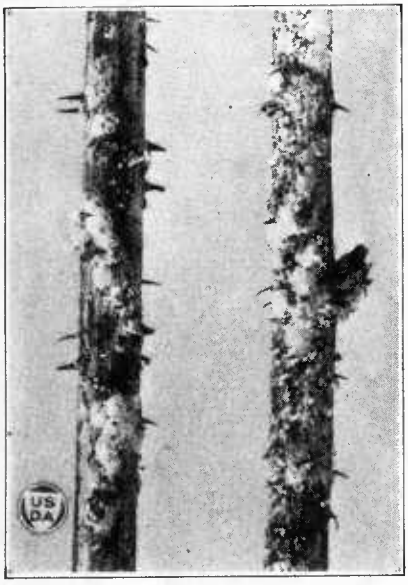

FIG. 78.—Twigs infested with rose scale.

Corn earworm ..... See Chrysanthemum.

Rose scale.[96]—The rose scale (fig. 78) occasionally occurs in greenhouses, but it is more frequently found on outdoor plants, such as roses, raspberries, and blackberries. The scales, both male and female, are snowy white and quite conspicuous in appearance.

Control.—See control of scales, under "Ferns," "Palms," and "Orchids."

White grubs ..... See Soil insects.

SMILAX.

The garden flea-hopper.[97]—When full grown the garden flea-hopper is similar to the tarnished plant-bug, except that it is smaller. In the short-winged form, however, it is more like the black flea-beetle in appearance and ability to jump. It inflicts considerable injury on smilax, chrysanthemum, and morning-glory under glass. Large numbers of the flea-hoppers feed on the underside of the leaves, puncturing them and killing portions of the tissue, so that they are disfigured by small irregular white patches.

[96] *Aulacaspis rosae* Bouché.

[97] *Halticus citri* Ashm.

Control.—Same as for plant-bug (see "Sweet pea"), except that smilax is very susceptible to injury by hydrocyanic-acid gas

	See—
Cabbage looper	Calendula.
Cutworms	Carnation.
Thrips	Carnation. Croton.
White fly	Ageratum.
Red spider	Rose.
Mite	Bulbs.

(See also "Ferns.")

SNAPDRAGON.

If hydrocyanic-acid gas is employed in the control of any of the insects on snapdragon which are listed below, do not use more than one-fourth of an ounce per 1,000 cubic feet of space.

	See—
Cyclamen mite	Cyclamen.
Leaf-tyer	Cineraria.
Caterpillars	Calendula.
Cutworms	Carnation.
Red spider	Violet. Rose.
White fly	Ageratum.
Budworm	Rose.
Mealybugs	Ferns.
Plant-bugs	Sweet pea.

SWEET PEA.

	See—
Red spider	Rose. Violet.
White fly	Ageratum.
Leaf-tyer	Cineraria.
Cutworms	Carnation.
Aphids	Rose.
Sowbugs	Soil insects.

PLANT-BUGS.

Several species of leaf-bugs often do considerable injury to flowering and ornamental plants, among which the tarnished plant-bug,[98] the four-lined leaf-bug,[99] and the dusky leaf-bug[1] are the chief offenders. These leaf-bugs are very troublesome pests on outdoor plants, and are apparently omnivorous feeders on virtually all weeds and miscellaneous vegetation, gaining entrance to greenhouses through open doors or ventilators.

Tarnished plant-bug.—The tarnished plant-bug (fig. 79) has been recorded as inflicting considerable injury to sweet pea, chrysanthemum, aster, dahlia, carnation, zinnia, and marigold, although a long list of food plants could be given. The adults as well as the nymphs injure the plants by piercing and then sucking the plant juices from the tender terminal growth (fig. 80) or by "stinging" the flower stalk just below the bud, producing "blind buds" or causing them to become badly distorted and later to wither and die.

---

[98] *Lygus pratensis* L. [99] *Poecilocapsus lineatus* Fab. [1] *Adelphocoris rapidus* Say.

The adults are recognized by their bronzy reflection, their oblong-shaped bodies, which taper toward the hind end, and triangular heads with prominent eyes. The color is variable, usually a brassy brown marked with yellowish and black dashes.

FIG. 79.—The tarnished plant-bug.

They are a little more than one-fourth inch in length and very active, taking to flight on the least disturbance. They are strong fliers and collect in abundance near favorable breeding and hibernating places. In their development they pass through five nymphal stages, in the first of which they are about one-twentieth of an inch long and of a yellowish green color. In the third stage the wing pads appear.

The adults hibernate between the leaves of mullein and other plants or under almost any débris and appear in spring. Eggs are laid in the blossoms of Compositae and the nymphs feed on the sap of the same plants. Mare's tail (*Erigeron canadensis*) is preferred, although this insect breeds on a variety of other plants. In about a month's time the first generation attain their full growth, after which all stages may be found throughout the summer until late October, when they may attack crops grown under glass.

Four-lined plant-bug.—The four-lined plant-bug has a wide distribution and feeds on practically the same host plants as the preceding species, although roses, deutzias, and dahlias are often "blasted," the young shoots becoming checked, drooping, and dying. Outdoors it is recognized as a particularly serious enemy of currants and gooseberries, in the younger shoots of which the eggs are deposited in lengthwise slits 2 or 3 inches below the tender tips. Subsequently the younger growth is attacked.

FIG. 80.—Injury to terminal growth by tarnished plant-bug.

The nymphs hatch from overwintering eggs in May and June. They are very active and dart from one side of the leaf to the other

when disturbed. They are very small, only about one-twentieth of an inch long, and recognized by their shiny bright red color, marked with large blackish spots. They become full grown in about 20 days, and during this period they molt five times. The adults are active until the end of July, when they may disappear. In greenhouses their injury has been noted early in March.

In size and shape the adult resembles somewhat the tarnished plant-bug, except that this species is yellowish or greenish, and marked with four black stripes.

The dusky leaf-bug.—Although the dusky leaf-bug is more commonly known to attack cotton, grains, and grasses, it is sometimes associated with the tarnished plant-bug as a pest in greenhouses. In 1905 Forbes mentioned it as attacking the evening primrose.

The bug when full grown is about one-fourth of an inch long, dark brown with a yellow border, and may be recognized by the bright red spots on the middle of the wing. The five nymphal stages are greenish, marked with red. The adults live over the winter, and there are two overlapping generations a year.

FIG. 81.—Ants attending a group of mealybugs. Their almost constant presence protects the mealybug from its natural enemies. (Woglum and Borden.)

Control.—Of prime importance in the control of these plant-bugs is the practice of clean culture in and around greenhouses and flower gardens, including the gathering and destruction by burning of all weeds, trash, and vegetation, especially all Compositæ, which serve as hiberating quarters.

The nymphs may be controlled by spraying with the tobacco solutions, or other contact insecticides. Applications should preferably be made during the cool morning hours when the nymphs are sluggish. Spraying for the adults in the heat of the day is of no value, because of their marked activity. Adults may be collected early in the morning or late in the day by beating them from the plants into pans containing water covered with a film of kerosene.

Dusting with pyrethrum has been successfully used in controlling them, when it has been impractical to spray with contact poisons. According to Gibson and Ross,[2] heavy applications of hydrated

[2] Dominion of Canada Dept. of Agric., Bul. 7, N. S., 1922.

lime alone, or of a lime-nicotine dust containing 5 per cent nicotine sulphate, showed considerable promise as a repellent when applied as a dust with a hand blower.

Fumigation with hydrocyanic-acid gas at the rate of one-half ounce per 1,000 cubic feet or with tobacco smudges should prove effective.

SOIL INSECTS AND PESTS.

Ants.—Ants frequently become very troublesome by building their nests and galleries under the roots of plants, in the pots, or along and on the outside of the main stems. Their presence in greenhouses is generally associated with the presence of one or more species of "honeydew" producing insects, such as mealybugs (fig. 81), plant-lice, and soft scales. This association is due to the fact that ants are very much concerned about the welfare of these insects, protecting them from natural enemies by building shelters and also transferring them from time to time to young succulent growth. This interest on the part of the ants is rewarded by the "honeydew" or sweetish fluid, which the ants collect and transfer to their nests. This habit of the ants favors the use of poisoned baits in controlling them.

FIG. 82.—White ant, mature worker.

Control.—Ants may be satisfactorily controlled if not entirely eliminated from infested greenhouses by using a poisoned sirup as a bait. Dissolve 15 pounds of granulated sugar in 7½ pints of water and add three-fourths of an ounce of tartaric acid (crystallized). Boil these ingredients slowly for 30 minutes and allow to cool. Then dissolve three-fourths of an ounce of sodium arsenite in one-half pint of hot water and allow to cool. Combine the two solutions by thorough stirring. Finally add 1½ pounds of honey. Saturate small pieces of sponges with the poisoned sirup and distribute about the infested places sheltered with inverted thumb pots placed over them. The ants convey this material to their nests and die as a result of feeding on it.

Spray the walks, the soil under the pots and benches, and the woodwork with kerosene nicotine oleate.

Where only a few nests are concerned the ants may be destroyed by injecting a little carbon disulphid, kerosene, or gasoline into the opening by means of a small oil can or syringe. This can be done only when the nest is sufficiently far removed from the roots of plants and should not be used in direct contact with any growing plants whatever. Pouring boiling hot water into the opening of the nest is also quite effective in destroying them.

Termites or white ants.—Termites or white ants (fig. 82) have been found injuring geraniums, chrysanthemums, and other thick-stemmed greenhouse plants. These insects come up through the ground and form dirt galleries through the supports or burrow

through the bench legs and form galleries the entire length of the wooden benches. They kill a plant very quickly by eating out the main stalk of the root. Termites gain entrance to the potted plants through the drainage holes, and in the case of bench plants they work their way up directly through the woodwork in which they have their nests.

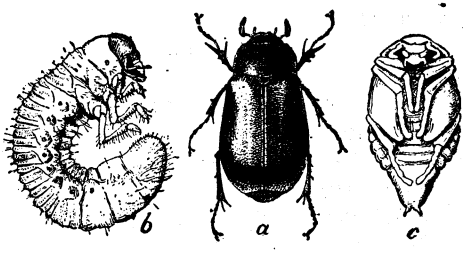

FIG. 83.—A white grub, or May beetle: *a*, Beetle; *b*, larva, or grub; *c*, pupa. Enlarged one-fourth. (Chittenden.)

Control.—In the case of potted plants, or if the benches can not be immediately replaced, soak the ashes or sand under the pots or the infested benches with kerosene nicotine oleate, or a 5 per cent solution of kerosene emulsion, or a solution of sodium cyanide, dissolving 1 ounce in each gallon of water. Carbon disulphid as recommended for ants (pp. 20, 72) may be used in moist soil which is more compact. In severely infested greenhouses the entire woodwork should be removed and replaced, preferably by upright steel frames set in concrete bases. If it is necessary to use wooden uprights, they should be set in concrete or rest on stones or bricks above the ground, all exposed surfaces of which should be frequently cleaned of dirt, so that the termites will not construct connecting galleries in the ground to the wooden uprights.

FIG. 84.—The spotted garden slug. (White.)

White grubs.—The larvæ of May beetles or "June bugs," which may be recognized from Figure 83, are frequently introduced into the greenhouses when the benches or beds are being replenished with composted sod. This is particularly true in the case of roses and chrysanthemums. The grubs feed primarily in the roots, causing the plants to wilt and eventually die.

Control.—Use carbon disulphid. Sterilize the soil, if heavily infested, before bringing into greenhouses.

Slugs.—In greenhouses and gardens slugs (fig. 84) often become insidious pests. They usually confine their attacks to young tender seedlings, although the large plants, such as chrysanthemum, marigold, snapdragon, cineraria, coleus, and geranium, are not immune from their attacks. They range from one-half inch to 4 inches in length, and their colors vary from a yellowish gray, or brown mottled with black, to dark gray and black. A sticky mucous secretion is given off from their bodies which adheres to any object that they crawl over, leaving a glistening trail behind them. They feed at night and in daytime their usual haunts are in damp and dark locations, especially under old and decayed wood or underneath flowerpots, where also the masses of translucent, light yellow eggs are laid.

Control.—All decayed boards or débris should be removed and the slugs treated to a liberal application of air-slaked lime or finely pulverized salt. Old boards and the edges of the compost pile may harbor eggs or young, and these should be examined carefully before they are carried into the house. Cutting beds may be protected by placing a border of salt, soot, or dry lime around them. As an effective bait, use boiled potatoes or sweet potatoes sprinkled with dry white arsenic or Paris green. Another remedy is to saturate the soil with mercuric chlorid solution.

Sowbugs or "pillbugs."—These creatures on being exposed to light are very active, although some forms roll themselves up into the shape of a round pill upon the least disturbance, hence the name "pillbug" (fig. 85). They are about one-half inch long, dark gray, and oval. Their flattened bodies have about seven pairs of legs. They are not true insects. Their usual abode is under some shelter such as decayed boards, flowerpots, in decayed manure, or any other dark place where decay is in progress. Cutting beds are preferred by them, although they will feed on the roots of orchids and ferns and the tender portions of other plants, such as carnations and sweet peas.

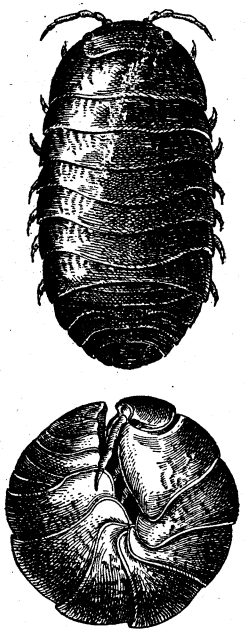

FIG. 85.—The greenhouse pillbug: Above, extended; below, contracted. Much enlarged. (Popenoe.)

Control.—Sprinkle the surface of the soil lightly with a dry mixture consisting of 9 parts sugar and 1 part dry Paris green or poisoned bran mash (p. 5). A similar remedy consists of 2 parts white flour, 2 parts sugar, and 1 part Paris green, and may be applied in the same manner.

Dry tobacco dust is very effective as a repellent. Spray with kerosene nicotine oleate under benches and on walks as described on page 7.

Prevention.—Destroy hiding places by cleaning up and burning refuse.

Millipeds.—These hard-shelled wormlike animals are often called "thousand legs." They are not true insects, from which they differ by having two pairs of legs on each body segment, whereas the adults of true insects have only three pairs of legs altogether. When disturbed they move along very rapidly and are easily recognized by their many legs as well as brown color and length of body. They attack principally the roots and stems of plants (fig. 86). Usually they are associated with the presence of manure which contains considerable decaying vegetable matter, and are abundant in damp places, especially under the flowerpots.

Control.—Vegetables dipped in Paris green or in dry arsenate of lead and placed about the benches provide a very effective remedy. Drenching the soil with mercuric chlorid, or sprinkling it with dry Paris green and sugar (1 to 9), as recommended for sowbugs, is also effective.

Roaches.—Roaches often become a nuisance and may do some injury to greenhouse plants. They are effectively controlled by fumigation with hydrocyanic-acid gas, one-half ounce to 1 ounce sodium

cyanide per 1,000 cubic feet of space, or by sodium fluorid sprinkled around their favorite haunts, or by phosphorus paste placed about on boards.

Grasshoppers and crickets [3] are easily subdued by arsenicals or by poisoned-bran mash, as recommended for cutworms.

Earthworms.—Often the soil of pots and flower beds becomes overstocked with earthworms and in some instances injury to the plants results. The worms are brought in with the soil or manure and breed quite rapidly under favorable conditions. Their habit of

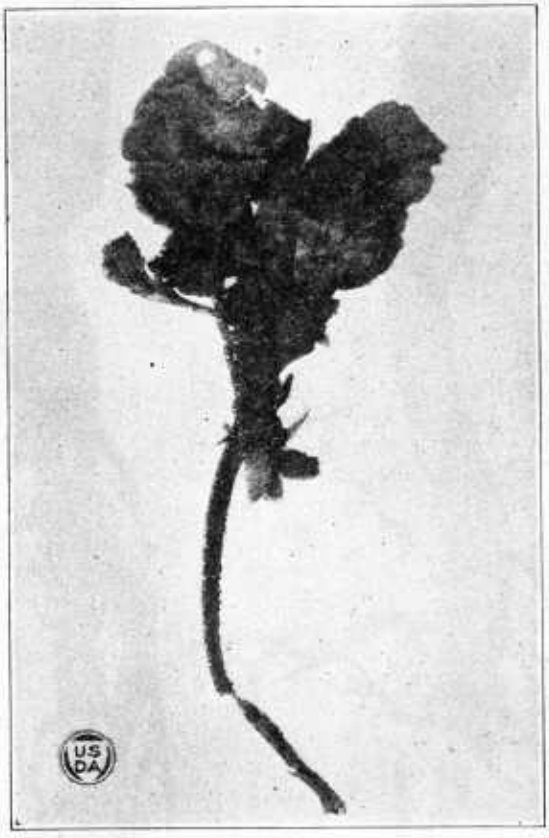

FIG. 86.—Pansy root injured by millipeds.

tunneling through the fine root systems of the plants is often damaging and destructive to plant culture.

Control.—Mercuric chlorid is the best remedy.

A saturated solution of limewater applied to the soil freely will destroy the earthworms. About 2 cupfuls of unslaked lime placed in a bucket of water, thoroughly agitated, and allowed to settle, will furnish the desired clear liquid. Tobacco dust thoroughly worked into the soil will also prove effective, and at the same time have some value as a fertilizer.

[3] The Asiatic or conservatory camel cricket, *Diestrammena japonica* Blatchley.

Wireworms.—The larvæ of click-beetles, better known as wireworms, may damage greenhouse plants by feeding on roots (fig. 87), and are brought into the house in the soil. The name "wireworm" has reference to their wiry, shiny, smooth, and round bodies, which vary in color from pale yellow to chocolate brown. They are about 1 inch long, live preferably in sandy soils, and require one or more seasons for development. The beetles are about one-half inch long,

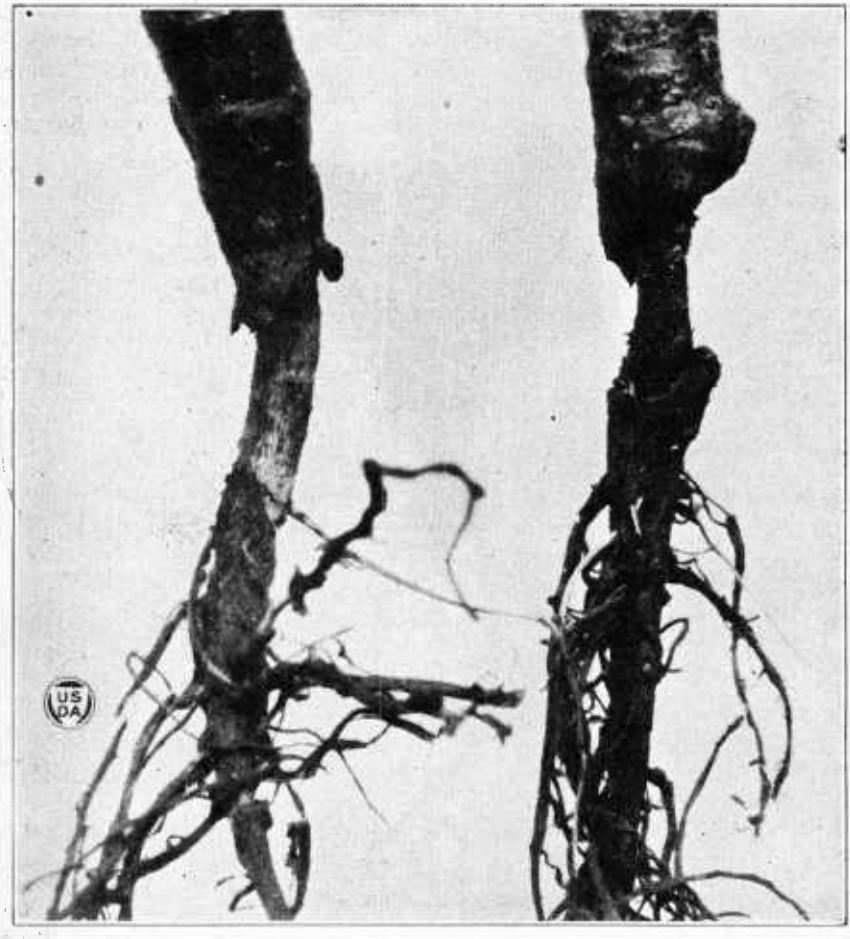

FIG. 87.—Aster roots injured by wireworms.

brown to black, very active, and cause a clicking noise when they jump, or if held between the fingers.

Control.—Sterilize the soil before filling beds or benches, or trap the wireworms under piles of rubbish, which should be examined often and all wireworms destroyed whenever found underneath.

SOIL STERILIZATION.

Soil remaining in greenhouses for a number of years may become so heavily infested with soil insects and other pests that it is nec-

essary to resort to drastic measures to destroy them. Where the proper facilities are available this may be accomplished by soil sterilization with live steam. This treatment has the additional advantage of ridding the soil of nematodes, bacteria, and certain disease organisms, as well as improving its physical condition.

To be effective the steam should be under 80 to 100 pounds pressure, and a temperature of 180° to 212° F. should be maintained in the soil for an hour or longer. Two methods of applying the steam are in use, the "inverted pan" and the "perforated pipe." The former consists of a galvanized sheet-iron pan 6 inches deep and 6 by 10 feet in size, with handles at each end for convenience in moving it. The sharp edges of the pan are forced into the soil to a depth of 4 inches. The other method requires a system of parallel perforated pipes, 1½ inches in diameter and any convenient length, having one end plugged and the other connected to 2-inch crossheads with high-pressure boiler connections. The holes in the underside of the pipes are one-eighth to three-sixteenths of an inch in diameter and about 12 inches apart, and the pipes also are 12 inches apart. These pipes are buried level in the soil to a depth of from 4 to 6 inches, and the surface of the soil leveled and covered with burlap or canvas to prevent the escape of the steam.

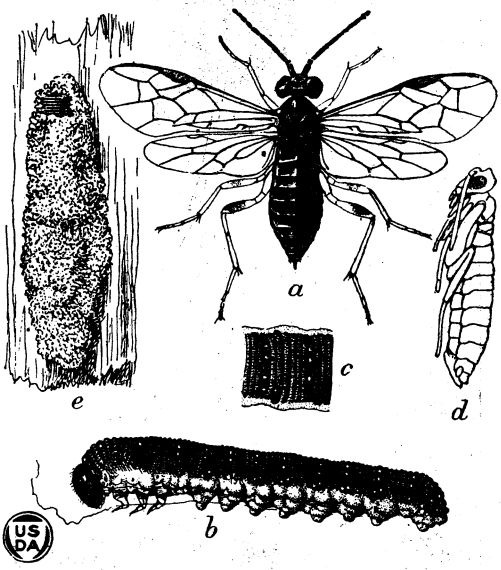

FIG 88.—Violet sawfly: *a*, Female sawfly; *b*, larva; *c*, abdominal segments of larva from above; *d*, pupa; *e*, cocoon. All except *c* four times enlarged. (Chittenden.)

It is economical of time and labor to have two or more sets of either type of the above equipment on hand so that while one is in operation the other can be prepared for use.

When potatoes which have been buried in the soil at a depth of about a foot are thoroughly cooked, the steam may be turned off, since this is an indication that the process has been of sufficient duration.

VIOLETS.

Red spider.—It is difficult to determine on which of the two crops, viz, roses or violets, the red spider is more destructive. When they once gain a foothold on either crop they are very hard to control, especially when syringing with water can not be resorted to as often as it should be. For further information see "Rose."

The violet sawfly.[4]—In the Northern States growers of violets and pansies sometimes find that their plants have been injured during the night by some unknown enemy. A close examination beneath the surface of the soil, or under the lowest leaves of the plants, will often reveal some bluish black, smooth caterpillars, about one-half inch long, when nearly full grown, conspicuously marked with minute white tubercular spots on the back and sides. These are the young or larvæ of the violet sawfly (fig. 88). During the earlier stages the caterpillars eat holes in the leaves, while in the later stages they feed mostly along the sides of the foliage and when present in large numbers, especially during late May or early June, may completely defoliate the plants (fig. 89). Injury may also result from the egg-laying habit, as a result of the eggs being laid in bunches within the tissues, causing the foliage to wither.

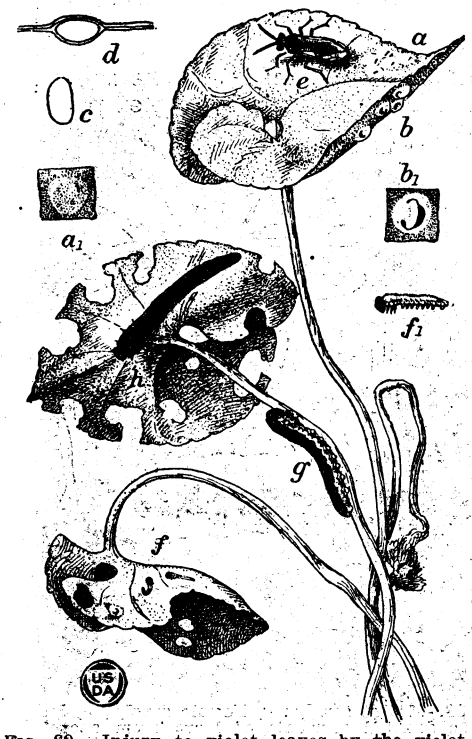

FIG. 88.—Injury to violet leaves by the violet sawfly: *a*, Egg cells on upper surface of leaf; a_1, an egg cell magnified; *b*, cells after escape of larvæ; b_1, one of same magnified; *c*, egg from above; *d*, egg in situ from side; *e*, female at rest on leaf; *f*, newly hatched larvæ on leaf; f_1, same enlarged; *g*, active stage of larva; *h*, full-grown larva feeding. *a*, *b*, *e*, *f*, *g*, *h*, Natural size; a_1, b_1, *e*, *d*, f_1, enlarged. (Chittenden.)

The female sawfly is four-winged, black, and about five-eighths of an inch long. During her three or four days of existence the small eggs are deposited within the leaf tissues, giving the leaf a blister-like appearance. Within 12 to 18 days the larvæ which hatch from these eggs work their way out of the tissues and begin feeding. During the daytime the younger larvæ may be observed on the underside of the foliage in a curved position like a letter J, while the older ones may be detected with their bodies fully extended on the stems near the ground. Growth of the larvæ is completed in about 30 to 32 days, after which very little feeding is done. They then seek decayed or soft wood or the stalks of pithy plants, in which they pupate, emerging as adults the following spring. The entire life cycle during the spring and summer requires about 8 to 10 weeks.

Control.—Hellebore diluted 50 times with flour and dusted on the plants has proved effective. Spraying with Paris green or arsenate of lead, or dusting with the dry mixture of arsenate of lead and superfine sulphur, as recommended on page 9, is also satisfactory.

[4] *Emphytus canadensis* Kirby.

Violet gallfly.[5]—In past years occasional records have been received indicating that the violet crops in many houses have been reduced from one-third to one-half as a result of injuries caused by the minute larvæ or maggots of small two-winged flies or gnats (fig. 90), which produce galls on the leaves. As the leaves push out from the crown of the plants they cause a distortion or curling, eventually stunting and arresting the normal growth and flower bud development. The gall-like structure is produced by folding the upper surfaces together (fig. 91); often a wet rot follows the injury and hastens the destruction of the affected leaves. When the white legless larvæ are ready to pupate they enter the soil, and it is thought that 10 days are required for that period. The parent gallfly, which is a small, slender two-winged individual, measures about one-twentieth of an inch in length, is rarely seen on the wing, and apparently stays close to the leaves on which it feeds. They are in abundance and most destructive in July and August, although they may occur as late as October and November.

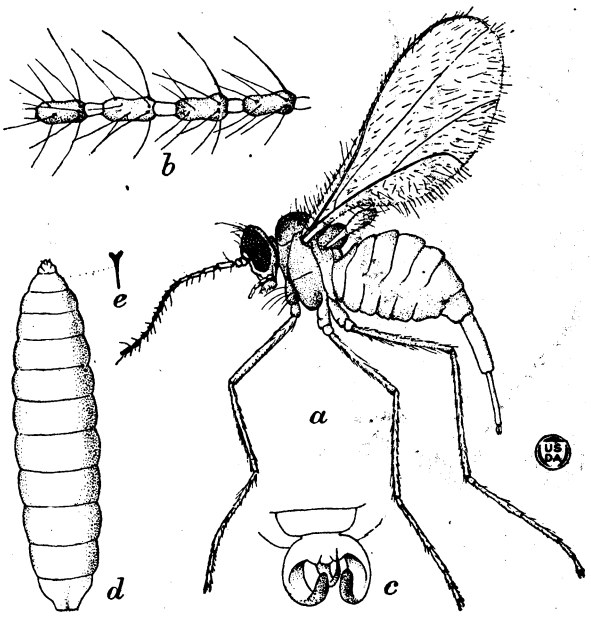

FIG. 90.—Violet gallfly. *a*, Female fly; *b*, female antennal joints; *c*, male genitalia; *d*, larva; *e*, breastbone of larva. *a*, *b*, Much enlarged; *c*, *d*, *e*, more enlarged. (Coquillett.)

Control.—According to some violet growers, injuries due to the gallfly may be kept at a minimum by holding the temperatures of the house at 60° F. during the daytime and about 40° F. at night. When their injury is first detected daily hand picking of the infested leaves should be very effective, because their infestations will usually occur only in definite localities or spots throughout the houses.

Spraying with nicotine solutions or smoking with tobacco should *not* be resorted to, owing to the spotting of the foliage or leaves likely to follow.

Mercuric chlorid, as recommended for the fickle midge (under "Ferns"), should be effective against the pupæ in the soil.

Nightly fumigation with hydrocyanic-acid gas against the adults, as recommended for the chrysanthemum midge, using one-eighth to

[5] *Diplosis violicola* Coq.

one-fourth ounce of sodium cyanide per 1,000 cubic feet of space for one hour, should also be effective.

Cutworms and caterpillars.—Owing to the several species of cutworms, and the long list of caterpillars and larvæ of many other moths which are known to feed on violets, it will probably be more desirable simply to refer to the control as given for cutworms under "Carnation" and for leaf-tyer under "Cineraria."

FIG. 91.—Leaves of violets showing injury by "gallfly" larvæ. Natural size. (From photograph by P. H. Dorsett.)

	See—
Aphids	Rose.
The common mealybugs	Coleus.
Greenhouse Orthezia	
Millipeds	Soil insects.
Sowbugs	
Slugs	
Wireworms	
White grubs	

MISCELLANEOUS POTTED AND BEDDING PLANTS.

Acalypha.
Amaryllis.
Aspidistra.
Asters.
Azalea.
Begonia.
Dracaena.
Fuchsia.
Geranium.
Gladiolus.
Gloxinia.
Heliotrope.
Impatiens sultani.
Ivies.
Lantana.
Larkspur.
Marguerite daisy
Pandanus.
Petunia.
Periwinkle.
Poinsettia.
Rubber plants.
Scarlet sage.
Stevia.
Verbena.

Since it is not within the scope of this bulletin to treat all crops which naturally fall into the category of greenhouse ornamental and flowering plants, the above list will aid the reader in associating them with the insects named below. Only the more important pests likely to attack them are included in this list, and direct reference is made to the plant under which the insect in question is discussed.

	See—
Greenhouse white fly	Ageratum.
Aphids	Rose.
Red spider	
Thrips	Carnation.
	Croton.
Mealybugs	Coleus.
Scale insects	Ferns.
	Orchids.
	Palms.
Greenhouse leaf-tyer	Cineraria.
Cutworms and caterpillars	Carnation.
	Calendula.
Fickle midge	Ferns.
Soil insects and pests	Soil insects.

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October 13, 1923.

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